(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
31 May 2001 (31.05.2001)

PCT

(10) International Publication Number
WO 01/39197 A2

(51) International Patent Classification[7]: G21C

(21) International Application Number: PCT/US00/31341

(22) International Filing Date:
15 November 2000 (15.11.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/448,402 24 November 1999 (24.11.1999) US

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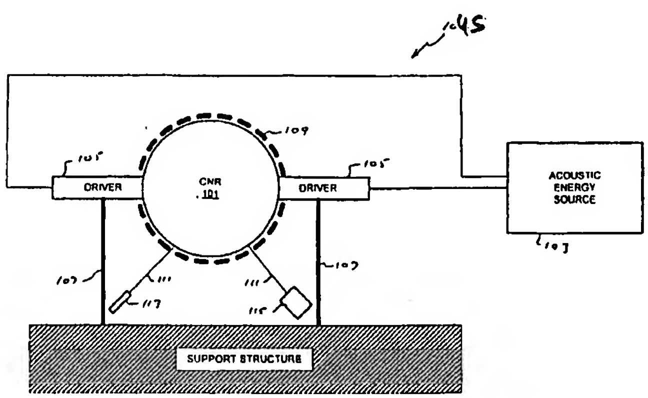
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *Without international search report and to be republished upon receipt of that report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** CAVITATION NUCLEAR REACTOR AND METHOD OF OPERATING SAME



(57) **Abstract:** A method and apparatus for driving nuclear reactions in a controlled manner within a cavitation nuclear reactor or CNR is provided. In general, the CNR is comprised of a solid material and, more particularly, comprised of a fuel material interspersed within a host material. The CNR can utilize any of a variety of different shapes. Energy, typically in the form of acoustic energy, is driven into the CNR with one or more drivers in order to create a pressure intensity pattern within the reactor. As a result of the pressure intensity pattern, at numerous locations within the reactor the energy is large enough to form small cavities or bubbles. Due to the phenomena of cavitation, the applied energy causes the newly formed bubbles to oscillate, undergoing a period of expansion followed by a period of bubble collapse. The velocity of the spherically converging material associated with the cavitation cycle, often times reaching supersonic velocities, is sufficient to achieve a density and temperature in excess of that required to drive a variety of different nuclear reactions including fusion, fission, spallation, and neutron stripping. If desired, an external heat source can be used to heat the material comprising the CNR, thereby promoting the desired nuclear reactions. In a specific embodiment, the CNR is driven at a frequency that either substantially matches a resonant frequency of the CNR or substantially matches an integer multiple of a resonant frequency.

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CAVITATION NUCLEAR REACTOR AND METHOD OF OPERATING SAME

FIELD OF THE INVENTION

The present invention relates generally to nuclear reactions and, more particularly, to a method and apparatus for promoting nuclear fusion, fission, spallatation, and neutron stripping reactions within an acoustically driven cavitation reactor.

BACKGROUND OF THE INVENTION

Cavitation is a well known phenomena in which small bubbles are formed and subsequently caused to expand and collapse through the application of acoustic energy. During the contraction phase of the cycle, the appropriately driven collapsing bubble causes a shock wave to be formed ahead of the collapsing bubble wall, resulting in a rapid increase in the temperature and the pressure within the bubble. If a sufficient temperature is reached, the bubble will briefly emit radiation, the spectrum of which is dependent upon the bubble temperature as well as the gas or gases within the bubble. The conversion of acoustic energy to optical energy is commonly referred to as sonoluminescence.

Numerous theories have been developed to explain the sonoluminescence phenomenon, although to date none of the theories appear adequate. Regardless of the theory, it is well agreed that extremely high bubble temperatures can be reached. Estimates place bubble temperatures between 10,000 and 1,000,000 degrees Kelvin.

Under appropriate conditions, the collapsing bubble can yield temperatures that are sufficient to drive fusion reactions. For example, U.S. Patent No. 4,333,796 discloses two different cavitation fusion reactors or CFRs. Each CFR is comprised of a reactor chamber and a plurality of acoustic horns coupled through the chamber walls. Within the reactor chamber is a liquid host metal such as lithium or beryllium into which hydrogen isotopes are distributed either as dissolved gas, as hydrides, or as small bubbles. The acoustic horns are used to vary the ambient pressure in the liquid metal, creating small bubbles that are then caused to expand and collapse. The resultant high

temperatures and pressures within the bubble and the host liquid are used to promote thermonuclear reactions of the hydrogen isotopes.

U.S. Patent No. 5,858,104 discloses a cavitation reactor chamber filled, in part, with a liquid. The chamber is coupled to a pressure source that allows the liquid to be pressurized to a static pressure different from the ambient atmospheric pressure. A pulsed acoustic shock wave is introduced into the liquid and reflected from a free surface of the liquid as a dilatation wave. The dilatation wave is focused on a desired location within the chamber, the desired location containing in at least one embodiment an object such as a biological cell, a pellet, or some other surface to be cleansed. The dilatation wave causes a bubble to form and expand while the static pressure causes the bubble to subsequently collapse and generate extremely high pressures.

U.S. Patent No. 5,659,173 discloses a technique for converting acoustic energy into other energy forms, the technique utilizing a feedback loop. The feedback loop monitors a characteristic of the emission and uses this characteristic to control the driving mechanism, thus allowing the process to be sustained for extended periods of time. Emission characteristics that may be monitored include the intensity of the produced energy as well as the repetition rate of the produced energy, assuming that the energy is in the form of pulses. In the disclosed system, the feedback loop may use the monitored information to alter the frequency or amplitude of the applied acoustic energy.

In at least one embodiment of the invention, the reactor is supported by streams of liquid directed at the reactor by individual liquid jet generators. For example, a spherical CNR can be supported with three generators directing streams of liquid towards the lower portion of the reactor in an approximately tetrahedral geometry and a fourth jet downwardly directing a stream of liquid at the top portion of the reactor. Preferably the liquid streams are pulsed using any of a variety of techniques in order to form streams of variable mass flow rate, *e.g.*, liquid droplets. As the streams impact the CNR, the desired acoustic impulses are generated. More preferably the liquid streams are also used to cool the reactor, providing a means of lowering the temperature of the reactor. As a consequence, reactor overheating is prevented thereby allowing more intense nuclear reactions to be established. Additionally, once the liquid streams are heated, they provide an efficient means of withdrawing the energy generated by exothermic nuclear reactions within the reactor.

What is needed in the art is a method and apparatus for easily and economically driving a variety of nuclear reactions. The present invention provides such a method and apparatus.

SUMMARY OF THE INVENTION

The present invention provides a method and apparatus for driving nuclear reactions in a controlled manner within a cavitation nuclear reactor or CNR. In general, a CNR according to the invention is comprised of a solid material and, more particularly, comprised of a fuel material interspersed within a host material. Energy, typically in the form of acoustic energy, is driven into the CNR with one or more drivers in order to create a pressure intensity pattern within the reactor. The drivers utilize any of a variety of different transducer types which convert electrical energy into acoustic energy. The exact characteristics of the pressure intensity pattern are dependent upon, among other factors, the size, shape, and material comprising the CNR; the number, design, and locations of the drivers; the amplitude and frequency of the source coupled to the CNR through the drivers; and the mechanical and thermal history of the CNR. As a result of the pressure intensity pattern, at numerous locations within the reactor the energy is large enough to form small cavities or bubbles. Preferably the creation of the bubbles is accompanied by the formation of small melt zones that enclose the bubbles. Due to the phenomena of cavitation, the applied energy causes the newly formed bubbles to oscillate, undergoing a period of expansion followed by a period of bubble collapse. The velocity of the spherically converging material associated with the cavitation cycle, often times reaching supersonic velocities, is sufficient to achieve a density and temperature in excess of that required to drive the desired nuclear reaction.

According to the invention, a variety of different nuclear reactions can be driven within the cavitation sites of the CNR. The possible nuclear reactions include fusion, fission, spallation, and neutron stripping. In one embodiment of the invention, fusion reactions are forced to occur within the solid CNR, for example using deuterium, tritium, and/or lithium as reactants. Although the fusion reactants can be loaded into a variety of host materials, preferably the host material is a metal of high acoustic impedance such as molybdenum or tungsten. Alternately, the host material can be selected on the basis of sound speed, cost, and its ability to absorb hydrogen. Applying this set of criteria, a suitable material is titanium. In another embodiment of the invention

that utilizes the high energy photons resulting from the extremely hot plasmas associated with heavy ion collisions in the cavitation bubbles, photo-dissociation fission reactions are forced to occur within heavy atoms such as uranium or plutonium. In another embodiment of the invention, neutron stripping reactions are forced to take place within the CNR between heavy isotopes, preferably those with a large thermal neutron capture cross-section, and light isotopes such as deuterium, tritium, and lithium. Examples of suitable heavy isotopes include gadolinium, cadmium, and europium.

In accordance with the invention, a CNR can utilize any of a variety of different shapes. Although the preferred shape for many applications is spherical, the CNR can also be fabricated in other shapes such as cylindrical, conical, cubic, or rectangular. Additionally the CNR can utilize an irregular shape, such as one in which one or more surfaces are covered by a plurality of depressions or one in which the overall shape is comprised of both curved and flat surfaces.

Material selection for the CNR, and more particularly reactant selection, is primarily driven by the desired nuclear reaction. In general, a host material is selected which preferably exhibits high thermal conductivity, high density, and high sound speed, thus promoting high shock wave velocities and the attendant generation of high temperatures. In the preferred embodiment of the invention the host material is comprised of titanium, tungsten, or gadolinium although other materials such as cadmium, molybdenum, rhenium, or osmium can also be used. In order to achieve the intended reaction, the reactants are loaded into the host material using any of a variety of well known metallurgical techniques. For example, a powder of the reactant can be mixed with a powder of the host to form a mixture of the required concentration. The mixture is then pressed into the desired shape and sintered. Alternately, the reactants can be loaded into a melt of the host material. Once loaded, the material can either be cast or drawn into the desired shape. If necessary, the cast or drawn material can be further shaped using machining techniques. Alternately, the host material can be loaded by exposing it to a high pressure of the desired reactant within a furnace. After loading the material can be machined as required. Alternately, electrolysis and/or cavitation can be used to load the exterior surface of the host material, after which the reactants can be driven into the interior.

Regardless of the technique used to load the reactants into the host material, preferably the completed CNR includes a reactant concentration gradient

wherein the lowest reactant concentration is at the exterior surface and the highest reactant concentration is at the center of the reactor. One technique of achieving such a gradient is to heat the completed CNR in a vacuum furnace or in a high pressure inert gas furnace. This heating step allows the reactant atoms to diffuse out of the reactor, thereby forming a reactant gradient. As a consequence of achieving the desired gradient, the majority of reactions take place at a distance from the exterior surface of the reactor. Since the reaction sites become mechanically weakened during reactor operation due to repetitive stress cycling, minimizing cavitation and reactions near the reactor surface results in a reactor with a relatively strong outer shell, thereby extending reactor operational life.

Generally the acoustic impedance of the fuel material and the host material will be different. In at least one embodiment of the invention the fuel material that is interspersed within the host material is of a lower impedance. As a consequence of this acoustic impedance mismatch, the fuel material preferentially refracts and concentrates the acoustic energy driven into the reactor, preferably causing the fuel material to undergo localized melting. Preferably in this embodiment the fuel material is loaded into the host material such that the fuel material density is highest at the center of the reactor, decreasing with increasing distance from the center of the reactor. As a result of this gradient, minimal cavitation and minimal nuclear reactions occur near the exterior surface of the CNR thereby delaying reactor failure due to material fatigue. Suitable material combinations include GdD_2 and W, LiD and W, LiD and Gd, D and Ti, and D and Pd.

In at least one embodiment of the invention, one or more heaters are used to heat the material comprising the CNR. As a result, less energy must be coupled into the CNR to form the cavities or bubbles, thereby indirectly promoting the desired nuclear reactions within the CNR. CNR heating can be achieved using a non-directed heat source such as a resistive heater, or using a directed heat source such as a laser, microwave heater, or inductive heater. In the preferred embodiment of the invention, once cavities have been formed within the reactor and nuclear reactions are occurring, the external heat source can be eliminated.

A variety of different energy sources can be used with the present invention, driving energy into the CNR with one or more drivers. Multiple drivers are preferred, as it then is easier to drive large amounts of energy into the CNR while generating complex pressure intensity patterns that exhibit a large number of pressure

intensity anti-nodes. Preferably the energy drivers are coupled to the CNR such that the generation of a large number of cavitation sites within a relatively small reactor area is avoided.

In the preferred embodiment of the invention, acoustic drivers are used to drive acoustic energy into the CNR, preferably at a frequency within the range of about 1 kHz to 20 GHz, and more preferably in the range of 50 kHz to 400 kHz. For example a piezo-electric crystal, preferably coupled to one or more resonant masses, can be coupled to the CNR. Alternately the CNR can be coupled to a driver system that is comprised of one or more projectile discharge systems, each of which directs a stream of projectiles at the surface of the CNR or at a suitable coupler. As each projectile collides with the CNR or the coupler, an acoustic wave impulse is imparted to the CNR. In a slight variation of this driver system, rather than directing a stream of projectiles at the CNR, a stream of liquid droplets is directed at the CNR. In an alternate embodiment of the invention, one or more microwave drivers are used to drive energy into the CNR. In this embodiment preferably the surface of the CNR is modified in order to improve the efficiency by which the microwave energy is absorbed by the reactor.

In at least one embodiment of the invention, the CNR is driven at a frequency that either substantially matches the resonant frequency of the CNR or substantially matches an integer multiple of the resonant frequency. Due to the resonance of the CNR, the pressure anti-nodes with the strongest intensity are located at or near the center of the reactor with the pressure intensity decreasing with increasing distance from the reactor's center. Hence a pressure intensity gradient is formed, resulting in minimal cavitation occurring near the surface of the CNR. Since the material around a cavitation site becomes mechanically weakened due to repetitive stress cycling, minimizing the number of cavities as well as the strength of the cavitation phenomena near the surface of the CNR reduces the effects of stress cycling. As a result, reactor failure due to material fatigue is delayed or eliminated.

In at least one embodiment of the invention, the CNR has a plurality of resonant frequencies. Multiple resonant frequencies may be due to the shape of the CNR, for example a shape such as a rectangular CNR has more than one resonant frequency. Alternately multiple resonant frequencies may occur in a CNR that is comprised of multiple layers, for example an inner core region of one acoustic impedance surrounded by one or more outer regions or layers of differing acoustic impedance. In this

embodiment the frequency of at least one driver is selected to substantially match at least one resonant frequency of the reactor. Alternately, the frequency of at least one driver is selected to substantially match an integer multiple of at least one resonant frequency of the reactor. Alternately, multiple drivers can be used in which multiple driving frequencies are selected that substantially match multiple CNR resonant frequencies or that substantially match integer multiples of multiple CNR resonant frequencies.

In at least one embodiment of the invention, the CNR is driven at a frequency that is substantially a non-integer multiple of a resonant frequency of the CNR. Preferably the driving frequency is also greater than the resonant frequency. As a result of this driving frequency, a pressure intensity pattern is formed in which pressure intensity anti-nodes are created throughout the reactor.

In at least one embodiment of the invention, a pressure intensity pattern is formed within the CNR in which the density of pressure anti-nodes substantially adheres to a predetermined pattern. Preferably the predetermined pattern is a density gradient in which the highest density of pressure anti-nodes is located near the center of the reactor while the lowest density of pressure anti-nodes is located near the exterior surface of the reactor. As a result of this gradient, minimal cavitation and thus minimal nuclear reactions occur near the exterior surface of the CNR thereby delaying or eliminating reactor failure due to material fatigue.

In at least one embodiment of the invention, multiple drivers are coupled to the CNR which are designed to drive energy into the CNR at different frequencies, thereby potentially providing more thorough excitation of the fuel material contained within the CNR. For example, the frequency selected for one driver may substantially match a resonant frequency of the reactor while the frequency selected for a second driver may be a non-integer multiple of the same resonant frequency. Additionally, when the reactor has more than one resonant frequency, either due to reactor shape or due to the use of multiple structures and/or layers, the use of different frequencies allows the reactor to be more efficiently driven.

In at least one embodiment of the invention, the multiple drivers coupled to the CNR provide more than one type of input energy, potentially leading to higher intensity pressure anti-nodes and more efficient fuel usage. For example, one or more microwave drivers and one or more non-microwave drivers can each be coupled into a single CNR.

In at least one embodiment of the invention, a coolant system is integrated with the CNR. The coolant system provides a means for lowering the temperature of the reactor in a controlled manner, thereby allowing more intense nuclear reactions to take place while preventing reactor overheating. Overheating can lead to reactor failure, for example due to the reactor temperature exceeding the melting temperatures of the host and fuel materials thereby terminating the reactor's ability to drive reactions. Additionally, the coolant system provides an efficient means of withdrawing the energy generated by exothermic nuclear reactions within the reactor. The coolant system can either pass coolant along at least a portion of the exterior surface of the CNR, for example through the use of a coolant jacket enclosing the reactor, or utilize one or more internal coolant passageways, thus allowing maximization of the ratio of the surface area to the volume.

In at least one embodiment of the invention, the CNR utilizes a multi-layered design comprising an inner core region surrounded by one or more layers. The acoustic driving energy is delivered to the inner core through the outer layer or layers using any of a variety of different acoustic drivers. In the preferred embodiment, the inner core is spherical and it is surrounded by a single, spherical layer. Alternately, the inner core and/or the outer layer or layers can be otherwise shaped, for example using a cubic, cylindrical, conic, or other shape. Preferably the inner core region contains the fuel material while the outer layer or layers are fabricated from a lower cost, high tensile strength material, thereby lowering the overall manufacturing cost while extending reactor life through the reduction of stress fatigue failures. Also preferably the acoustic impedance of the core region is lower than that of the outer layer or layers, thus improving the shock formation tendencies of the reactor.

In at least one embodiment of the invention, one or more microwave drivers are coupled to the CNR. Microwave drivers add flexibility to the design of the CNR since virtually any convenient geometry can be used that will allow penetration of the microwave energy into the reactor. Preferably the surface of the reactor on which the microwave energy impinges contains one or more surface features that are designed to attenuate microwave reflections and improve the reactor's microwave absorption characteristics. For example, the surface of the CNR can be covered with conical depressions, the size and shape of which are dependent upon the frequency of the microwave energy.

In at least one embodiment of the invention, the cavitation process within the CNR is used to create high energy photons that are used to artificially reduce the half lives of radioactive material. According to the invention, the radioactive material to be remediated is formed into a CNR, the CNR preferably performing dual functions. In particular, besides performing the primary function of providing a means for radioactive waste remediation, the CNR is also used as an energy source. The later function is performed by heating a coolant which is then used in conjunction with any of a variety of different power extraction techniques.

A further understanding of the nature and advantages of the present invention may be realized by reference to the remaining portions of the specification and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic illustration of a nuclear reaction system in accordance with the invention;

Fig. 2 schematically illustrates pressure wave intensity patterns;

Fig. 3 illustrates several CNR configurations;

Fig. 4 is an illustration of an acoustic driver utilizing a coupling member and an oscillating member separated by a gap;

Fig. 5 is an illustration of an acoustic driver similar to that shown in Fig. 4 except that it provides a means of obtaining two acoustic impulses per oscillation cycle;

Fig. 6 is an illustration of an acoustic driver utilizing one or more streams of particles;

Fig. 7 is an illustration of an acoustic driver similar to that shown in Fig. 6 except that the particles from the driver impact a coupler which determines the impulse shape driven into the reactor;

Fig. 8 is an illustration of an acoustic driver utilizing a jet of liquid droplets;

Fig. 9 is an illustration of a microwave driver;

Fig. 10 is an illustration of a pair of mounting members attached to the displacement nodes of a cylindrical reactor;

Fig. 11 is a block diagram of a system used to withdraw energy from the cavitation nuclear reactor of the present invention;

Fig. 12 is an illustration of a CNR that includes an inner core region surrounded by an outer shell;

Fig. 13 is an illustration of several reactors, each describable in topological terms as a single handled reactor; and

Fig. 14 is a cross-sectional view of a hollow cylindrical reactor system that includes an interior coolant passageway.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

Fig. 1 is a schematic illustration of a nuclear reactor system 100 in accordance with the invention. At the core of system 100 is a cavitation nuclear reactor (hereafter, CNR) 101 within which the desired reaction, *e.g.*, fusion reaction, takes place. Regardless of the reactor configuration, CNR 101 is comprised principally of a solid material that may or may not include a means for heat removal (*e.g.*, cooling jacket, heat pipes, *etc.*). Acoustic energy from a source 103 is coupled to CNR 101 via one or more drivers 105. CNR 101 is held by one or more support members 107 that are preferably designed to have minimal impact on the energy patterns within CNR 101.

According to the invention, acoustic energy is coupled to CNR 101 through drivers 105. As schematically illustrated in Fig. 2, the acoustic energy from drivers 105 results in a pressure intensity pattern within CNR 101. The exact characteristics of the intensity pattern are dependent upon, among other factors, the size, shape, and material comprising CNR 101; the number, design, and locations of drivers 105; the frequency of source 103; and the mechanical and thermal history of CNR 101 (*e.g.*, how long CNR 101 has been in operation, the locations of previously formed cavities, *etc.*). As a result of the intensity pattern, at numerous locations within CNR 101 the energy is high enough to form small cavities or bubbles within the solid material, the bubbles being between about 0.1 and about 100 micrometers in diameter. Preferably the intensity pattern also causes localized heating and the creation of small melt zones, the bubbles being formed within the melt zones, thus taking advantage of the differences between liquids and solids in their respective abilities to support shear stress. Due to the cavitation phenomena, the applied acoustic energy causes the newly formed bubbles to oscillate. During oscillation the bubbles first expand and then collapse. In the preferred embodiment of the invention, the spherically converging material associated with the cavitation process attains supersonic velocities, thus leading to a density and temperature

in excess of that required to drive the desired nuclear reaction. Furthermore, in the preferred embodiment the bubbles or cavities undergo repetitive cavitation cycles. It should be understood, however, that under the appropriate conditions, *e.g.*, sufficient input energy, appropriate fuel, *etc.*, a single bubble cavitation cycle is sufficient to cause the desired nuclear reaction to take place within that bubble.

As previously noted, the pressure intensity pattern within the CNR is dependent upon a variety of material and driver characteristics. Accordingly, a variety of pressure intensity patterns can be created within the reactor. For example, and as illustrated in Fig. 2, if a CNR 201 is driven by a driver 203 at a frequency that is not an integer multiple of a resonant frequency of the reactor and that is preferably greater than the resonant frequency, a pressure intensity pattern develops in which pressure intensity anti-nodes exist throughout the reactor. These anti-nodes, two of which are shown in Fig. 2 at a pair of locations 205, occur where there is a convergence of acoustic energy (*i.e.*, basically the phenomena of three-dimensional constructive interference). Alternately, CNR 201 can be coupled to a driver 207 operating at a resonant frequency or an integer multiple of a resonant frequency. Due to the resonance of the structure, in this example the strongest pressure anti-node will exist at the center of CNR 201 at a location 209 with the intensity of the pressure anti-nodes decreasing with increasing distance from the center of the reactor. Alternately, the CNR may be comprised of two or more individual structures such as an inner sphere 211 surrounded by an outer shell 213. As in the single structure design previously described, driver 215 can either drive the reactor at a resonant frequency, or some integer multiple thereof, or it can drive the reactor at a non-resonant frequency. Achieving resonance in a multi-structure reactor such as that shown is much more difficult than in a single structure reactor due to the multiple material compositions, acoustic impedance variations, shapes, positional relationships of the structures, *etc.*, that leads to a complex resonance pattern which includes multiple fundamental resonance frequencies. Given that resonance in a multi-structure reactor can lead to increased intensity within the pressure anti-nodes due to phase matching of the individual acoustic energy components, preferably the reactor is driven such that reactor resonance is achieved. It should be understood, however, that driving the reactor with sufficient energy eliminates the requirement for reactor resonance. Regardless of whether the reactor is comprised of a single structure or multiple structures, and as previously noted, the reactor can be coupled to either one or to multiple drivers. Note that if multiple

drivers are used they need not operate at the same frequency. For example in a reactor configuration utilizing multiple structures, *e.g.*, inner core 211 and outer shell 213, each driver can be designed to operate at a resonant frequency of one of the individual structures. In this case beating of the frequencies will occur, *i.e.*, the periodic rise and fall of the resonant energy. It should be understood that although spherical reactors are shown in Fig. 2, the invention is not so limited. The use of resonant and non-resonant frequencies in both single structure reactors and multi-structure reactors is applicable to both spherical and non-spherical reactors.

In an alternate embodiment, one or more heaters can be used to indirectly aid the formation of cavities and hence the nuclear reactions occurring within CNR 101. In this approach the bulk material is heated, thus reducing the amount of acoustic energy that is required to melt localized regions of the solid material. For example, CNR 101 can be substantially enclosed by a resistive heater 109. Alternatively, a heat beam 111 from one or more heat sources, *e.g.*, a laser 113 or a microwave or inductive heater 115, can be directed at the outer surface of CNR 101. Assuming an exothermic CNR design, typically after the cavities have been formed within the reactor and nuclear reactions are occurring, there is no longer any need or benefit to applying heat from an external source.

The present invention offers several advantages over conventional nuclear techniques such as laser inertial confinement fusion (ICF) and Tokamak magnetic confinement fusion. First, as the bubble collapses, the imposed acceleration results in an increase in the density of material within the bubble, thus leading to an increased nuclear collision probability at the end of bubble collapse. Second, since the bubble contents are ionized upon collapse, there is no further loss of energy during multiple particle interactions due to ionization. As a result, multiple particle interactions can occur, each having sufficient energy to generate a nuclear reaction, assuming the proper collision geometry. Third, during the collapse of the bubble, all of the atoms are primarily moving towards the center of the bubble leading to the inertial confinement of the hot plasma. Fourth, resonance in the present reactors leads to a higher Q than is attainable using conventional techniques. Fifth, the reactors of the present invention are significantly less expensive than the systems required to implement either magnetic or laser inertial confinement fusion.

Reactor Design

As illustrated in Fig. 3, CNR 101 can utilize any of a variety of different shapes. For example, CNR 101 can have a spherical shape 301, a cylindrical shape 303, a conical shape 304, a rectangular shape 305, or an irregular shape 307. A CNR in accordance with the present invention can also utilize one or more hollow portions 309, preferably for use with a liquid coolant thus providing improved cooling and heat extraction. Examples of such configurations include a cylinder 311, a donut-shaped CNR 313, and a rectangular shape 315. It is understood, however, that the shapes shown in Fig. 3 are intended to be illustrative only as there are limitless configurations that can be used with the present invention. The size and shape of CNR 101 are primarily determined by the available acoustic energy, the number of drivers, and the type and intensity of the desired nuclear reaction.

In the preferred embodiment of the invention, the CNR is operated in a mode designed to achieve a gradient in the intensity of the pressure anti-nodes with the intensity of the pressure anti-nodes decreasing with increasing distance from the center of the reactor. Given that the material around individual cavities becomes mechanically weakened due to repetitive stress cycling, a benefit of the gradient CNR configuration (hereafter referred to as a GCNR) is to provide a relatively strong outer shell in which the mechanical stresses are at a minimum, thereby keeping the reactor intact for an extended period of time. In contrast, a reactor that is not operated utilizing the intensity gradient configuration, *e.g.*, CNR 201 with driver 203, will form cavities at or near the surface of the reactor, leading to relatively rapid reactor failure primarily due to material fatigue fractures similar to those observed in materials subjected to ultrasonic radiation for extended periods of time.

Another benefit of the GCNR design is to provide nuclear radiation shielding. Depending upon the type of nuclear reaction that is promoted within the CNR, one or more radioactive by-products can be formed. Therefore by driving the nuclear reactions near the center of the reactor and minimizing or eliminating nuclear reactions from occurring near the reactor's exterior surface, the outer layer of the reactor will provide radiation shielding, the efficiency of which depends upon the radioactive by-products formed as well as the thickness and material of the outer layer.

There are several different ways to achieve a gradient reactor configuration. For example, and as previously described, the reactor can be driven at a

resonant frequency, or an integer multiple thereof, resulting in a gradient in the intensity of the pressure anti-nodes. Thus, for example, in a spherical reactor with a single resonant frequency, the maximum pressure anti-node intensity is at the center of the reactor and decreases with increasing distance from the center of the reactor. Alternately, the gradient can be achieved in the number, rather than the intensity, of the pressure anti-nodes. In this type of GCNR the highest density of pressure anti-nodes is located at the center of the reactor, with the density decreasing with increasing distance from the center of the reactor. Alternately, the composition of the reactor can be varied in such a manner as to achieve a GCNR. For example, a fuel material having a low acoustic impedance can be loaded into a host material with a high acoustic impedance such that the fuel material density is highest at the center of the reactor, decreasing with increasing distance from the center of the reactor. Examples of suitable material combinations include, but are not limited to, GdD_2 and W, LiD and W, LiD and Gd, D and Ti, and D and Pd.

As previously noted, the present invention utilizes a solid rather than liquid reactor. Although the material selection for CNR 101 depends upon the desired nuclear reaction, preferably the host material has a high thermal conductivity, a high sound speed, and a high density, thus promoting high shock wave velocities and the attendant generation of high temperatures. In addition, preferably the host material has a higher melting temperature than the fuel material, and more preferably that the melting temperature of the host material is greater than the vaporization temperature of the fuel material. As a consequence of these requirements, preferably the host material is a metal although other materials, such as ceramics, can also be used as the host material. In the preferred embodiment of the invention, CNR 101 is fabricated from titanium, tungsten, or gadolinium, although a variety of other host materials can be used such as cadmium, molybdenum, rhenium, osmium, hafnium, iridium, niobium, ruthenium, or tantalum.

In order to accomplish the desired nuclear reactions, the proper reactants must be loaded into CNR 101. A variety of well known metallurgical techniques can be used to load the reactants, thus only brief descriptions are provided herein. Powder metallurgy is one technique by which the desired reactants can be loaded into the lattice structure material comprising the CNR. For example, a powder of a reactant (*e.g.*, TiD, LiD, or GdD_2) can be mixed with a powder of the parent lattice (*e.g.*, Ti, W, Gd, Os, Mo) to form a mixture of the desired concentration which can then be pressed into the desired reactor shape, *e.g.*, a sphere, using a hot isostatic press or other means. Preferably the

fuel powders have diameters in the range of 1 to 100 micrometers, and more preferably in the range of 1 to 10 micrometers. The host powders have diameters as small as economically feasible with nanophase powders being preferred. The compressed structure is then sintered. Among other advantages, powder metallurgy provides an easy technique for controlling both the concentration and placement of the reactants within the parent lattice of the CNR.

Another technique for loading reactants is to bubble the desired reactant, for example deuterium, into the melted host material. After the host material is loaded with the reactant, it is either cast or drawn into the desired shape. If necessary, the cast or drawn material can be further shaped by machining.

Yet another technique for loading reactants is to expose the host material to a high pressure gas of the desired reactant in a furnace, *e.g.*, a deuterium furnace. For example, a titanium or tungsten host material can be exposed to high pressure deuterium using this technique. Alternately, a source of a high pressure gas of deuterium or other reactant can be attached to a host material which is then placed within a furnace. The reactant, *e.g.*, deuterium, will flow through the metal lattice, particularly if the host material is in the form of a drawn bar. The host material can be machined into the desired reactor shape before or after loading. Preferably reactant loading is improved by loading at a high temperature or by using a glow discharge to ionize the reactant and break-up the molecules into free atoms that can more easily penetrate into the metal lattice.

Yet other techniques for loading reactants are electrolysis and cavitation. By performing electrolysis and/or cavitation on the exterior surface of the host material, the reactants can be driven into the interior. Migration of the reactants through the host material typically follows imperfections in the grain structure.

Regardless of the technique used to load the reactant into the host material of the reactor, preferably the loaded reactor is placed in a vacuum oven or in an oven utilizing a high pressure inert gas such as argon. Inert gases, *e.g.*, argon, do not readily penetrate into the interior of the reactor. The purpose of this heating step is to allow certain reactant atoms, *e.g.*, deuterium and tritium, to diffuse out of the reactor. Since the reactant atoms will diffuse first from the outermost layer of the reactor and last from the center of the reactor, the reactor will develop a reactant concentration gradient wherein the lowest reactant concentration is at the exterior surface and the highest reactant concentration is at the center of the reactor. As a consequence of this additional step a

GCNR is formed as previously described, thus providing a reactor in which the mechanical integrity of the outermost material has been improved, leading to increased reactor life.

Driver Design

The present invention can utilize any of a variety of acoustic drivers. It is understood, however, that these drivers are not limited to use with the solid core CNRs of the present invention, but can also be used with a conventional CNR utilizing a liquid host medium. Typically the acoustic driver is coupled to a frequency source. The desired frequency depends upon the characteristics of the host material and the desired pressure intensity pattern, although for a metal host preferably the frequency is in the range of 1 kHz to 20 GHz, and more preferably in the range of 50 kHz to 400 kHz. In the preferred embodiment the output frequency of source 103 is adjustable over a relatively large range, thus allowing the frequency to be fine tuned to the characteristics of a specific CNR. Additionally, in the preferred embodiment the frequency output of source 103 is periodically altered to at least a small degree, *e.g.*, ± 10 % of the driving frequency, thereby changing the acoustic interference pattern and insuring that the locations of the cavities formed within the reactor vary. By varying the locations within the reactor where cavitation occurs, the reactor will operate for a longer period of time prior to the occurrence of a mechanically induced failure. Varying the cavity locations also allows regions in the reactor core containing unused fuel to be excited, thereby providing efficient fuel usage. It should be noted, however, that due to the continual formation and collapse of cavities within the reactor, the frequency characteristics of the reactor are continually changing, thus automatically varying the locations of cavitation within the reactor and reducing the need to vary the frequency output of source 103.

As previously noted, a CNR has well defined frequency characteristics, *e.g.*, one or more resonant frequencies, that are dependent not only upon the material comprising the CNR but also the size and shape of the CNR. The fundamental resonant frequency characteristics can be estimated using the sound speed of the material comprising the CNR as well as the dimensions of the CNR. An initial driver frequency can then be selected on the basis of this estimate, utilizing either a fundamental resonant frequency of the CNR or some integer multiple thereof, assuming resonant excitation is desired. The driving frequency can then be fine tuned by monitoring some aspect of the

reactor, such as the amount of acoustic or white noise generated by the collapsing cavities within the reactor, and adjusting the driving frequency to maximize the selected characteristic. Alternately, the fundamental frequency or frequencies of the reactor can be experimentally determined using techniques well known by those of skill in the art.

In accordance with the present invention, preferably resonant standing waves are generated within the reactor, thus leading to the formation of large numbers of cavities. As a consequence, a frequency greater than the fundamental frequency of the CNR is coupled through the drivers into the CNR.

A CNR in accordance with the present invention can utilize 1, 2, 3 or more drivers. It is understood, however, that preferably more than one driver, and typically more than 2 drivers, are used in order to generate pressure intensity patterns with a large number of pressure anti-nodes. The pressure intensity pattern generated within the reactor is dependent on the number of drivers and, as previously noted, the driver input frequency or frequencies as well as the frequency characteristics of the reactor. In addition, the pressure intensity pattern is also controlled by the driver locations and the manner in which the drivers are coupled to the reactor. It has been found that the mounting locations are virtually limitless (*e.g.*, opposed drivers, multiple adjacent drivers, *etc.*) although some locations are preferred in order to minimize generating an exceedingly large number of cavitation sites within a relatively small area of the reactor, thus potentially leading to premature reactor failure.

Figs. 4-9 illustrate a few of the drivers that can be used with the present invention. It is understood that the present invention can use either a single driver (*e.g.*, as shown in Figs. 4-5, and 9) or multiple drivers (*e.g.*, as shown in Figs. 6-8). Furthermore, if multiple drivers are used they can be of either the same or different type and of either the same or different frequency. In addition it is understood that the presently disclosed drivers can be coupled to solid core reactors other than the spherical CNR shown in Figs. 4-8 or the cubic CNR shown in Fig. 9 as well as conventional reactors utilizing liquid host materials.

Driver 400 of Fig. 4 is comprised of a coupling member 401, a gap 403, and an oscillating member 405. Member 405 oscillates along axis 407. During each cycle of oscillating member 405, an end portion of member 405 comes into contact with an end portion of member 401, eliminating gap 403 and generating a shock wave that is coupled via member 401 into CNR 101. The amplitude of the generated shock wave is

proportional to the energy coupled to member 401 by member 405 upon contact. The frequency is determined by the oscillation frequency. Although a variety of techniques can be used to oscillate member 405, *e.g.*, magnetostrictive devices, preferably either member 405 is comprised of a piezo-electric crystal or one or more piezo-electric crystals 413 are coupled to member 405, member 405 acting as a resonator mass. In the later configuration typically a second resonator mass 415 is employed with crystal(s) 413 interposed between the two resonator masses.

Fig. 5 illustrates a variation of the driver shown in Fig. 4. As with driver 400, driver 500 utilizes an oscillating member 405 that may be comprised of a piezo-electric crystal or be driven by one or more piezo-electric crystals 413. Similarly, an additional resonator mass 415 can be used. Driver 500, however, utilizes a coupling member 501 that includes a trough 503. Oscillating member 405 is comprised of a complimentary portion 505 that loosely fits within trough 503 such that upon each complete oscillation cycle portion 505 contacts trough 503 twice, first against surface 507 and then against surface 509.

Preferably if the driver utilizes piezo-electric crystals mounted between a pair of resonator masses, *e.g.*, Figs. 4 and 5, a pair of piezo-electric crystals are used such that the adjacent surfaces of the two piezo-electric crystals are of the same polarity. This configuration minimizes potential grounding problems associated with the driver assembly.

Fig. 6 illustrates an acoustic driver system 600 based on a shot peening technique. System 600 utilizes one or more projectile discharge systems 601, each directing a stream of individual projectiles 603 at CNR 101. As each projectile 603 collides with the surface of CNR 101, an acoustic wave impulse is generated. Driver system 600 may also utilize laser peening in which a pulsed laser source is directed at CNR 101, resulting in the generation of acoustic pulses.

In a slight variation of the previous driver system, driver system 700 shown in Fig. 7 utilizes a coupler 701 mounted to CNR 101. The stream of projectiles 603 impact coupler 701 rather than the outer surface of CNR 101. Coupler 701 controls the shape of the impulse generated by projectiles 603 within CNR 101 as well as providing a wear surface that can be designed to be easily replaceable.

In another aspect of the invention, if reactor 101 is surrounded by sufficient projectile discharge systems 601 producing streams of projectiles 603 of

sufficient mass and at a sufficient repetition rate, reactor 601 can be held in place without the use of additional support members. In this embodiment, as shown in Figs. 6 and 7, one or more temporary support members 605 are used to hold the reactor in place until discharge systems 601 are activated and the system has entered into a state of levitation equilibrium.

Fig. 8 is an illustration of an acoustic driver system 800 utilizing one or more pulsed liquid jet generators 801. Each liquid jet generator 801 directs a liquid jet, for example comprised of water, at CNR 101. A variety of techniques can be used to pulse liquid jet generators 801 in order to form a stream of liquid droplets 803 that generate acoustic impulses within the reactor upon impact against CNR 101 or a suitable coupler 805. Alternately, as opposed to a stream of individual droplets, liquid jet generators 801 can be pulsed to form a liquid stream in which the mass of the stream varies as a function of time but in which the stream is not broken-up into individual droplets. Techniques for pulsing liquid jet generators 801 include, for example, an ultrasonically excited needle restriction can be placed within the jet causing modulation of the fluid flowing through the jet, and thus the formation of droplets 803. Alternately, the fluid can be ultrasonically driven, resulting in modulation of the pressure at the tip of the jet as well as modulation of the fluid flow rate. Alternately, jet generator assemblies 801 can be acoustically modulated, thereby altering the mass flow rate of the fluid exiting the jets.

Driver system 800 offers several advantages over a conventional acoustic driver. First, as previously described in reference to Figs. 6 and 7, it is possible to hold the reactor in place assuming that sufficient force can be applied to the reactor at a sufficient number of locations around the reactor's perimeter, thus offsetting the gravitational force applied to the reactor. This system preferably utilizes one or more temporary support members 605 during initialization of driver system 800. Second, by varying the angle of incidence of individual jet generators 801 away from the normal to the reactor, the reactor can be forced to gradually spin, thus altering the internal resonance pattern and insuring that cavitation occurs at continually varying sites. Third, the liquid streams can be used to cool the reactor. The heating of the liquid provides a means of withdrawing the energy generated through the nuclear reactions occurring within the reactor (*e.g.*, by producing steam). Fourth, there are no parasitic losses of acoustic energy resulting from the reactor supports since the driver system provides the required support.

If liquid jet driving system 800 is used to support the reactor, preferably a spherical or a cylindrical CNR is used. Preferably a minimum of four jet generators 801 are used, thus providing a stable support configuration, although typically a cylindrical CNR will require additional jets. If a spherical CNR is used, preferably three of the jets direct fluid flow towards the lower portion of the reactor, the jets positioned in an approximately tetrahedral geometry. The fourth jet is preferably downwardly positioned, directing fluid flow along a path normal to the ground plane. The desired system balance can be achieved by altering the fluid pressure in the lower three jets compared to the upper jet. Alternately, if the same pressure is used in all four jets, the location of the reactor will self-adjust until it attains a stable position. Alternately, the positions of the jets can be adjusted to obtain the desired balance, for example by moving the three lower jets closer to the central axis and further away from a tetrahedral geometry. Alternately, additional jets can be used, for example additional jets can be located underneath the reactor in order to provide increased vertical thrust to offset the weight of the reactor.

In another embodiment of the invention, the acoustic driver or drivers used to generate the pressure waves within the reactor, and ultimately to drive the cavitation phenomena, are cooled. Preferably the cooling system used by the drivers is separate from any cooling system coupled to the reactor, thus allowing higher reactor temperatures and greater system efficiency to be achieved without overheating the driver components.

Microwave Drivers

The previously described drivers are based on the coupling of acoustic energy to the CNR. In an alternate approach shown in Fig. 9, microwave energy is coupled into the material comprising the CNR. As shown, CNR 901 is constructed of sintered powders, wire mesh, or other materials that efficiently absorb microwave energy.

For the purposes of the present example, CNR 901 is comprised of two powders; a powder consisting of 5 micrometer particles of GdD_2 and a second powder consisting of 5 micrometer particles of tungsten. In this example the ratio of tungsten to GdD_2 is selected to be about 1000 to 1, thus providing an average spacing of 50 micrometers between adjacent GdD_2 particles. It is understood that other materials as well as combinations of more than two powders can also be utilized by the present invention. In addition, other particle sizes, *e.g.*, between about 0.1 and about 100

micrometers can be used as well as other particle spacings, *e.g.*, between about 10 and about 1000 micrometers.

The use of multiple powders, *e.g.*, the two powders used in the present example, result in the formation of localized regions of low acoustic impedance into which the acoustic energy is preferentially refracted and concentrated. Thus in the present example the regions containing GdD_2 are the first to melt, both due to the concentration of energy in these regions as well as the lower melting temperature of GdD_2 compared to tungsten.

The frequency of microwave source 903 is determined by the particle size although typically the frequency is between about 1 MHz and 20 GHz. For a 5 micrometer particle as in the present example, microwave frequencies in the range of 1 GHz are preferred since, assuming a sound speed of 5 kilometers per second in the metal, a 1 GHz frequency corresponds to an acoustic wavelength of 5 micrometers. Matching the frequency of the incident microwave energy to the particle size insures that the energy will be efficiently absorbed by the particle, setting the particle structures into resonance. It will be understood that other frequencies can cause the particles to resonant, although not as efficiently as a matching frequency. Alternately, the excitation frequency of microwave source 903 can be designed to match the average fuel particle spacing. In this example with a spacing of 50 micrometers between fuel particles, an excitation frequency of 100 MHz will achieve the desired frequency match. Alternately, the excitation frequency of microwave source 903 can be designed to sweep a range of frequencies, preferably from a high frequency to a low frequency, thus causing particle structures throughout the reactor to resonant. An advantage of this approach is that it provides a means of matching the microwave energy to an individual cavity for a longer period of time since, during cavity formation and growth, the resonant frequency of the cavity will vary. Additionally, since there are variations in the diameter of the particles as well as the spacing of the particles, this approach can provide more efficient fuel usage.

One advantage of this driver is that it provides added flexibility in the design of the CNR since virtually any convenient geometry can be used that will allow penetration of the microwave energy. For example, CNR 901 has a cubic geometry. In order to aid the penetration and focusing of the incident microwave radiation from source 903 into CNR 901, surface 905 adjacent to source 903 includes one or more conical depressions 907. It should be understood that depressions 907 need not be conically

shaped. Rather, depressions 907 can utilize any geometry that sufficiently attenuates the microwave reflections and improves the reactor's microwave absorption.

Reactor Support

In the preferred embodiment of the invention, the reactor mounting system exhibits minimal damping of the acoustic characteristics of the CNR thus insuring that the CNR acts as an under-damped resonator. This restraint is important in order to provide efficient coupling of acoustic energy into the reactor, thereby allowing the desired pressure intensity patterns to develop within the reactor.

As previously noted, the same means used to drive the cavitation phenomena can also be used to support the reactor. For example, either particles (*e.g.*, as shown in Figs. 6 and 7) or liquid droplets (*e.g.*, as shown in Fig. 8) of sufficient mass and frequency can be used to maintain the desired position of the reactor. In this approach no additional support members are required once the acoustic drivers are operational.

In an alternate approach, one or more support members are attached either directly or indirectly to the CNR. In this approach it is desirable to couple the members to the CNR at a displacement node, *i.e.*, a location exhibiting little if any movement during the oscillation of the reactor. For example as shown in Fig. 10, a cylindrical reactor 1001 driven by an acoustic driver 1003 located at one end of the reactor and generating a resonance pattern within the reactor will exhibit a plurality of displacement maximums 1005 and a plurality of displacement nodes 1007 (assuming that the injected energy has a wavelength less than the length of reactor 1001). By coupling support members 1009 to CNR 1001 at displacement nodes 1007, little energy is lost.

It is understood that in many reactor configurations, given the shape of the reactor as well as the number, location, and frequency of the drivers, it may be impossible to identify one or more true displacement nodes. For these configurations the mounting members are coupled to the reactor at a location of minimal displacement, thus minimizing the damping effects of the mount.

Nuclear Reactions

In order to drive nuclear reactions, two nuclei must be forced to either collide or to come into extremely close proximity to one another. Due to mutual Coulomb repulsion, however, this requires that the velocities associated with the nuclei be

very large. Furthermore, for increasing atomic charge and thus increasing Coulomb force, a correspondingly higher kinetic energy is required to force the nuclei to be close enough to undergo a nuclear reaction.

The kinetic energy of a material is directly related to its temperature. More specifically, the temperature of a material refers to its average kinetic energy; the average being based on the distribution of kinetic energies associated with the individual atoms that comprise the material. The kinetic energy of an individual atom scales linearly with the atom's mass, and scales with the square of the atom's velocity.

In traditional systems designed to generate fusion reactions such as those employing either magnetic or laser confinement fusion processes, heavy ions can have deleterious effects on the overall process. For example, in a magnetic confinement fusion process, heavy ions in the plasma do not contribute to the production of fusion energy and they cool the plasma through radiation.

In contrast to either of these fusion processes, the present invention benefits from the use of heavy ions. This benefit arises from the cavitation phenomenon itself. Specifically, during the period of bubble collapse within the cavitation cycle, the walls of the bubble are inwardly accelerating at approximately the same rate regardless of whether the bubble walls are comprised of heavy ions, light ions, or both. This is the result of the heavy ions, *e.g.*, tungsten, and the light ions, *e.g.*, deuterium, having approximately the same charge to mass ratio and therefore approximately the same acceleration profiles. At the end of the collapse period, the material comprising the opposing bubble walls collides with approximately the same velocity, resulting in the formation of a plasma in which the temperature is the average kinetic energy of the colliding material. Since kinetic energy scales linearly with mass as previously noted, the effective temperature of a heavy ion is much higher than that of a light ion, and therefore the temperature of a plasma comprised of heavy ions, *e.g.*, tungsten, will be much higher than that of a plasma comprised of light ions, *e.g.*, deuterium. Accordingly, by using a host material comprised of a high mass material such as gadolinium, tungsten, osmium, iridium, or uranium, the temperature of the plasma formed within the collapsing bubbles is higher than would otherwise be achievable, leading to improved nuclear reaction capabilities.

Given that the kinetic energy of an atom is proportional to the square of its velocity, the sound speed of the host material is even more important than its mass. Thus

while doubling the mass of the host can lead to up to twice the plasma temperature, doubling the sound speed can lead to up to four times the plasma temperature. Suitable high sound speed host materials include beryllium, titanium, tungsten, and uranium. Of these, tungsten and uranium are ideal candidates as they have both a high mass and a high sound speed.

Additionally, and in accordance with the invention, both the surface tension and the vapor pressure of the host material are considered during the host material selection process. A large surface tension leads to an improvement in the sphericity of the collapsing bubble and hence improved bubble wall acceleration. A reduction in the vapor pressure helps to achieve a smaller diameter in the final, collapsed bubble. Since the collapsing bubble walls are undergoing acceleration, the further a cavity collapses, the greater the peak velocity achieved by the atoms. Hence a reduced vapor pressure leads to a higher plasma temperature in the collapsed cavity.

Typically, materials that exhibit a low vapor pressure also exhibit a high surface tension thus providing dual benefits to the present invention. In general, the preferred host material is a metal, and more preferably, a metal with a high melting temperature. Suitable materials include titanium, tungsten, osmium, iridium, molybdenum, tantalum, and uranium.

Specific nuclear reactions are discussed in more detail below.

<u>Fusion Reactions:</u> In a fusion reaction multiple light nuclei, *e.g.*, light isotopes, are joined to form a heavier nucleus, *e.g.*, a heavier isotope. Using the present invention, a fusion reaction can be forced to take place within the solid core CNR using a variety of different fuels. For example, possible reactions include, but are not limited to, deuterium (*i.e.*, D+D), deuterium and tritium (*i.e.*, D+T), deuterium and lithium (*i.e.*, D+Li), or tritium and lithium (*i.e.*, T+Li). Preferably the desired reactants are loaded into a reactor comprised of either titanium or tungsten, although a variety of other materials can also be used (*e.g.*, gadolinium, cadmium, rhenium, osmium, and molybdenum). The advantage of a titanium reactor is that less incidental radioactive isotopes, *e.g.*, beta isotopes, are formed during reactor operation than with tungsten. Tungsten, however, allows the reactor to operate at higher temperatures without mechanical failure, thus leading to a more efficient system.

<u>Fission Reactions:</u> Fission reactions occur when the nuclei of heavy atoms, *e.g.*, uranium and plutonium, spontaneously split into multiple pieces (commonly two, occasionally three pieces) of approximately equal size. Fission can be forced to occur by bombarding a heavy nucleus with neutrons, protons, deuterons, or gamma rays. Due to the extreme conditions of the CNRs of the present invention, the nuclei involved in the hot plasmas of the cavitation bubbles exchange high energy virtual photons as they reverse their convergent momentum. When the energy of these photons is great enough, they cause the spontaneous fission of the involved nuclei. Among other applications, the artificially induced fission reactions can be used to artificially reduce the half life of any radioactive materials within the cavitation region.

<u>Spallation Reactions:</u> The present invention can also be applied to heavy isotope spallation reactions, which result from heavy ion collisions. Although this reaction requires higher temperatures than those required by light isotope fusion, the obvious benefit of this reaction is its use in eliminating radioactive waste produced by other sources (*e.g.*, fission reactors). In spallation reactions two nuclei collide at high energy causing a proton, neutron, or alpha particle to break away from the heavy nucleus, often converting a radioisotope into a stable nucleus.

<u>Neutron Stripping Reactions:</u> In another application of the present invention, heavy isotope reactions are forced to take place within the solid core CNR. In this reaction, commonly referred to as neutron stripping, a heavy isotope with a large thermal neutron capture cross-section, preferably greater than 10 barns, is forced to react with a light isotope (*e.g.*, deuterium, tritium, or lithium). Suitable heavy isotopes include, but are not limited to, gadolinium, cadmium, and europium. Alternately, in at least one embodiment of the invention, the heavy isotope is a radioactive isotope.

The neutron stripping reaction occurs via quantum tunneling of neutrons from the bound states in the light nuclei to the heavier nuclei and is accompanied by an energy release of approximately 4 MeV. Typically the reaction requires a higher activation temperature than that required for a light isotope reaction.

As previously described, in the present reactor the plasma temperature achieved at the end of the collapse of the cavity is typically greater for heavier elements than for light elements. This result is due to the fact that the temperature is the average

kinetic energy of the particles in a material. As a consequence, the present reactor is ideally suited for neutron stripping reactions, for example where a deuteron is used to transfer a neutron to a second nucleus such as gadolinium.

The neutron stripping reaction in a CNR can be enhanced through the use of high neutron cross section isotopes. For example, boron, cadmium, europium, gadolinium, samarium, dysprosium, iridium, and mercury all offer high neutron cross section isotopes. Particularly, gadolinium offers an extremely high neutron cross section as does one isotope of cadmium. Alternately, the rate of reactions and hence the rate of energy production can be improved by artificially increasing the neutron cross section of the fuel material, *e.g.*, Gd^{157}, using a suitable isotopic separation technique, *e.g.*, atomic vapor laser isotope separation or AVLIS.

In a preferred embodiment, specific undesirable end products are avoided by removing isotopes with a mass number one less than that of the undesirable end product prior to initializing the neutron stripping reaction. Thus, for example, by removing ${}_{64}Gd^{158}$ and/or ${}_{64}Gd^{160}$ prior to the neutron stripping reaction, the formation rate for beta reactive isotopes ${}_{64}Gd^{159}$ and/or ${}_{64}Gd^{161}$ can be greatly reduced.

Reactor Cooling

The process of cooling the CNR serves many purposes. First, it allows higher temperatures to be reached during cavitation, thus allowing more intense nuclear reactions to take place within the reactor without the reactor undergoing mechanical failure. Second, as previously noted, the cooling means can be used to support the reactor. Third, coolant heating provides one of the most efficient means of withdrawing the energy generated from exothermic nuclear reactions.

Fig. 11 illustrates one system 1100 for withdrawing energy from a CNR through steam generation. As shown, a CNR 1101 is driven by three acoustic drivers 1103 which are coupled to an acoustic energy source 1105. A coolant jacket 1107 surrounds reactor 1101 which is coupled to a source of coolant 1109. After the coolant is heated, it is withdrawn from jacket 1107 and used to power a steam turbine/electrical generator 1111 which produces electricity along lines 1113. As will be understood by those familiar with the art, power generation system 1100 is only one way in which energy can be withdrawn from CNR 1101. For example, steam turbine 1111 can be replaced with a heat exchanger. Additionally, besides generating electricity, the system

can be used in a locomotion device, heating system, *etc.* Typically system 1100 also includes means for recirculating the coolant, for example through the use of a condenser 1115 and a pump 1117.

Applications

The present invention can be used in a variety of applications. Although the principal application of the present invention is as an energy source, the invention can also be used for remediation and transmutation applications. Each application will be described in further detail.

Power Generation

The present invention is ideally suited as a means of efficiently providing power. As noted with respect to Fig. 11, a CNR can be used to heat water which, in turn, can be used in conjunction with a steam generator or other power generation system. Furthermore, given the scalability of the CNR, the system can be used as a small, high efficiency energy source, for example for use in a variety of locomotion systems (*e.g.*, automobiles, trains, ships, satellites, *etc.*) or as a large scale energy source capable of generating immense quantities of power. Preferably in the later application multiple CNRs are used in combination.

In a related application, the energy can be withdrawn from the CNR in the form of heat. Although the system can be used as a simple radiant heat source, preferably a liquid is heated by the CNR. The heated liquid can then be used to heat a building or other structure. The heated liquid or fluid can also be used with a magneto-hydrodynamic (*i.e.*, MHD) generator, directly converting the kinetic energy, *i.e.*, heat, generated by the CNR into electrical energy. A sodium potassium mixture, or NaK, is one fluid suitable for use in a MHD generator.

A CNR can also be used to provide a safe nuclear fission power plant. In a conventional fission power plant, a fission chain reaction is initiated and controlled with the use of control rods that modulate the number of neutrons captured by the fuel rods. In contrast, in a CNR fission reactor cavitation is used to artificially excite the fission reactions and control the level of reactivity. Therefore by discontinuing the application of acoustic energy to the reactor, the fission reactions end and the generation of heat is rapidly and significantly reduced. Thus, as a consequence of the CNR fission reactors

always operating in a sub-critical mass condition, if the reaction driving systems fail, nature automatically terminates the reaction.

Remediation and Transmutation

Through the application of heavy isotope spallation reactions, *i.e.*, heavy ion collisions, the present invention can be used in a variety of remediation applications such as eliminating radioactive waste. For example, spent nuclear fission reactor fuel rods can be formed into a shape suitable for a CNR as described above (*e.g.*, sphere, cylinder, *etc.*). By applying acoustic energy and driving the cavitation process within the CNR, regions of intensely hot plasma are formed at the center of each collapsing cavity. The hot plasma creates high energy photons which cause the radioactive nuclei to decay, thereby artificially reducing the half lives of the radioactive material. Additionally, not only is the radioactive waste burned up rather than buried as is the current practice, a CNR remediation device generates heat that can be used to generate electricity and offset the radioactive waste disposal costs.

Heavy ion collisions can also be used to generate a variety of isotopes which can be used for medical testing, laboratory instrumentation, *etc.* For example, a CNR driving deuterium-deuterium or deuterium-tritium reactions can be used as a neutron source, thus allowing the user to control both the creation of neutrons as well as the flux density. Thus as opposed to having to handle radioactive materials which are continuously emitting neutrons, the user would be afforded the same level of control which is common to conventional medical x-ray machines. Alpha and proton spallation also allows synthesis of expensive elements such as platinum or gold from inexpensive elements such as mercury.

Examples of Specific Embodiments

1) Radioactive Waste Remediation Device

As previously noted, the cavitation process within the CNR can be used to create high energy photons that cause radioactive nuclei to decay, artificially reducing the half lives of the material. In one approach to fabricating a radioactive waste remediation device a spent fuel rod is formed into a cylinder 10 centimeters in diameter and 120 centimeters long. The spent fuel can also be formed into other reactor shapes, such as those previously described, or into a cylinder of different dimensions. Preferably if a

cylinder is formed from the radioactive waste, its length is a multiple of its diameter, thus providing stronger pressure intensity interference patterns. It should be understood that the present configuration is meant to be illustrative only.

The sound speed of radioactive waste depends upon the composition of the waste. In general, the sound speed of a metal is in the range of 1,500 to 6,000 meters per second although some materials have a significantly higher sound speed, *e.g.*, beryllium with a sound speed of 12,000 meters per second. Typical fuel rods are comprised of metals in which the sound speed is in the range of 3,000 to 5,000 meters per second. Accordingly, this example assumes that the material comprising the spent fuel rod to be remediated has a sound speed of 4,000 meters per second.

Assuming the above noted speed of sound, a cylinder with the given dimensions has a natural resonant frequency of 40 kHz. Although the cylindrical CNR does not have to be driven at this resonant frequency, preferably it is driven at a resonant frequency or some integer multiple thereof in order to form the desired interference pattern of internal pressure nodes and anti-nodes. At the pressure anti-nodes, the intensity of the acoustic actuation is particularly strong, thus causing the formed cavities to violently collapse and drive more nuclear reactions. Thus the present cylindrical CNR is driven at 40 kHz, 80 kHz, 120 kHz, *etc.*, the higher the frequency the greater the number of internally formed interference pressure anti-nodes.

The interference pattern within the cylindrical CNR is not due solely to the reflections from the ends and the radial mode of oscillation. There are also reflections of wave energy that have been refracted, following trajectories other than simple radial or axial directions. Therefore preferably the driving frequency is optimized by monitoring a characteristic of the reactor such as the amount of acoustic or white noise produced by the cavitation process in the reactor and selecting a driving frequency that maximizes this characteristic. Although the use of white noise is preferred, it should be understood that other reactor characteristics can also be used to optimize the driving frequency. For example, the amount of heat produced by the reactor can be monitored. The heat production response time of the reactor, however, is slower than the acoustic signal response time.

It should be understood that it is not necessary to accurately determine the speed of sound for the spent fuel material if the above technique is used to optimize the CNR reactions. Additionally it should be understood that there are many frequencies in

which violent cavitation will take place within the cylindrical CNR as evidenced, for example, by the white noise output of the reactor. By shifting the driver frequency from one strong interference frequency to another, or even shifting the frequency within a relatively narrow band of frequencies centered at a strong interference frequency, the locations of the active cavities will shift. In this manner it is possible to burn up, *i.e.*, use up, the radioactive isotopes in numerous locations throughout the volume of the cylindrical reactor.

To excite the acoustic resonance within the cylindrical CNR, any of the previously described driver technologies can be used. For example, piezo crystals and acoustic horns can be coupled to both ends of the cylinder. Preferably the intensity of the sound energy is large enough to excite a large number of acoustic nodes, thereby increasing the rate of remediation, without melting the reactor. The heat generated by the reactions occurring within the CNR is removed using jets of a coolant, *e.g.*, water, which is used, in turn, with standard turbine or other power extraction technologies. If a metal coolant is used, the heat can be converted into electricity using standard MHD technologies.

As the radioactive material is remediated, less and less material is available for the CNR reaction, leading to a decrease in heat and energy production. Due to this decrease, eventually it becomes uneconomical to operate a CNR remediation facility. At this point the radioactive materials can be separated out, concentrated, and formed into new CNR reactors thus allowing further remediation of the radioactive materials. In the preferred embodiment of the remediation reactor, the elements that lead to water soluble radioactive isotopes, *e.g.*, iodine, are preferentially removed, thus further limiting the risks of hazardous radioactive materials entering the ground water system during storage.

In an alternate embodiment of the radioactive waste remediation CNR, the radioactive materials, *e.g.*, spent fuel rods, are loaded with deuterium thus allowing neutron stripping reactions in addition to spallation and induced fission reactions. A mixture of deuterium, gadolinium, and uranium, for example, will increase the intensity of the virtual photonic exchanges due to the energy released by the deuterium-gadolinium neutron stripping reactions in the hot plasma. In particular, by loading the radioactive isotopes with deuterium, the acoustic impedance of the material is lowered leading to an increase in the acoustic energy converging on the radioactive material. As a result, the

efficiency of the radioactive isotope remediation process is improved. Alternately, acoustic energy focussing can be achieved by alloying a high acoustic impedance radioactive isotope with a low acoustic impedance metal such as magnesium.

2) Layered CNR

As previously noted, it is advantageous to utilize an intensity interference pattern in which the intensity of the pressure anti-nodes varies from low near the reactor surface to high at the reactor center. This configuration, previously termed a GCNR, extends the life of the reactor by minimizing the mechanical stresses placed on the outer shell, thereby providing a strong outer shell that encloses the primary reaction sites.

The CNR embodiment illustrated in Fig. 12 improves upon this concept by utilizing a layered design. Although the CNR shown in Fig. 12 surrounds an inner core region 1203 with a single layer 1205, it is understood that the core can be surrounded by more than a single layer. The acoustic energy is delivered to inner core 1203 through the outer layer or layers utilizing any of the acoustic drivers that have previously been described. It should also be understood that although a spherical configuration is shown, the invention is not so limited. For example, a layered cube, a layered cylinder, a layered rectangular shape, and a layered random shape are also envisioned. It should be understood that the shape of the outer layer or layers need not be the same shape as the inner core. The inner confined region can be spherical, cubic, or otherwise shaped. The unifying aspect of this embodiment is the confinement of the desired fuel material within one or more exterior layers of a different, preferably non-fuel material.

Preferably inner core 1203 is fabricated from the desired fuel material while outer layer 1205 is fabricated from a lower cost, high tensile strength material, thereby lowering the overall manufacturing cost while simultaneously extending reactor life through the reduction of stress fatigue failures. Also preferably the acoustic impedance of core 1203 is lower than that of layer 1205 thus improving the shock formation tendencies of the reactor.

Although the embodiment shown in Fig. 12 can be used for any of the disclosed cavitation driven nuclear reactions, the present example is based on the neutron stripping process. Accordingly core region 1203 is comprised of an enriched isotope of a material with a high neutron cross section such as Gd^{157} (*i.e.*, a neutron cross section of approximately 254,000 barns). Enriched material (*e.g.*, gadolinium, cadmium, *etc.*) can

be obtained using a variety of known enrichment techniques which will not be described in detail herein (*e.g.*, atomic vapor laser isotope separation).

Layer 1205 is preferably comprised of a non-fuel material such as tungsten, titanium, or molybdenum that is capable of delivering the acoustic energy from the driver or drivers to core region 1203. An advantage of tungsten is its high sound speed, high density, and high acoustic impedance. Utilizing an exterior layer with a higher acoustic impedance than the central core region leads to an increase in the velocity of the compression wave initiated by the driver as the compression wave passes the interface between the two materials. As a consequence, higher shock wave velocities and higher temperatures can be obtained within the collapsing cavities or bubbles.

The use of tungsten, or a similar material, for layer 1205 offers other advantages. For example, it has a high mechanical operating temperature, thus allowing high temperature reactions to take place within the reactor without causing the ultimate failure of the reactor through melting.

3) Improved Coolant Flow CNR

As previously noted, the principal method of removing energy from the CNR is through the use of a heat exchanger. For example as shown in Fig. 11, a coolant jacket can be fitted to the CNR, the coolant jacket providing a means of passing a coolant along the exterior surface of the CNR. The coolant not only allows the reactor to operate at a higher temperature and efficiency, but also provides a way to draw energy away from the reactor. The energy content from the heated coolant can be extracted using any of a variety of techniques, *e.g.*, steam turbines, radiators, *etc.*

One method of optimizing both the extraction of energy from the reactor and the achievable reactor temperature is to maximize the ratio of the surface area to the volume. For example as shown in Fig. 3, a thick walled hollow cylinder such as CNR 309 allows coolant to flow along both an exterior surface and an interior surface of the reactor. Similarly CNR 311 allows coolant to flow along both the exterior surface and multiple interior surfaces of the reactor. In use, cavitation reactions are driven within the walls of the reactor.

As will be understood, there are limitless combinations of coolant passageways and reactor designs that can be used with the present invention. One method of describing this aspect of the invention is through the use of topology. For

example any reactor that includes a single coolant passageway, regardless of the shape of the reactor, can be described in topological terms as having a single handle. Similarly any reactor that includes two coolant passageways can be described as having two handles. Thus all of the reactors (*i.e.*, cylindrical reactor 1301, spherical reactor 1302, and cubic reactor 1303) shown in Fig. 13 are equivalent in topological terms since each includes one handle.

Fig. 14 is a cross-sectional view of a cylindrical CNR 1401, providing additional detail for a single, exemplary reactor. It should be understood that CNR 1401 is only meant as an example of a single-handled reactor as there are countless variations of such reactors. CNR 1401 includes an interior coolant passageway 1403 running along the axis of the reactor. A coolant jacket 1405 encloses the reactor, the jacket preferably being surrounded by thermal insulation 1407. Coolant, *e.g.*, water, is pumped into an inlet 1409, causing the coolant to pass along the interior reactor passageway 1403 and the exterior reactor surface prior to exiting the jacket through one or more coolant outlets 1411. One or more acoustic drivers 1413, *e.g.*, piezo drivers, are coupled to CNR 1401 which drive the cavitation reactions.

As will be understood by those familiar with the art, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Accordingly, the disclosures and descriptions herein are intended to be illustrative, but not limiting, of the scope of the invention which is set forth in the following claims.

WHAT IS CLAIMED IS:

1. A cavitation nuclear reactor, comprising:

a reactor, wherein during operation said reactor is comprised of a solid material interspersed by a plurality of cavitation bubbles, wherein said reactor has at least one resonant frequency;

a frequency source outputting a frequency of substantially an integer multiple of said at least one resonant frequency; and

at least one acoustic driver coupled to said reactor at at least one location, said at least one acoustic driver coupled to said frequency source and driving acoustic energy of said substantially integer multiple of said at least one resonant frequency into said reactor, wherein said acoustic energy, said at least one location, and a plurality of reactor characteristics define a pressure intensity pattern within said reactor, wherein said plurality of cavitation bubbles occur at a portion of a plurality of pressure intensity anti-nodes defined by said pressure intensity pattern, wherein said plurality of cavitation bubbles undergo at least one complete cavitation cycle comprising a period of bubble expansion and a period of bubble collapse, and wherein a plurality of nuclear reactions occur within a portion of said plurality of cavitation bubbles during said cavitation cycle.

2. The cavitation nuclear reactor of claim 1, wherein said pressure intensity pattern includes an intensity gradient.

3. The cavitation nuclear reactor of claim 2, wherein said intensity gradient varies from high intensity near a center location of said reactor to low intensity near an exterior surface of said reactor.

4. The cavitation nuclear reactor of claim 1, wherein said plurality of reactor characteristics include shape, size, material, mechanical history, and thermal history of said reactor.

5. The cavitation nuclear reactor of claim 1, wherein said plurality of cavitation bubbles are between about 0.1 micrometers and about 100 micrometers in diameter.

6. The cavitation nuclear reactor of claim 1, wherein a shape corresponding to an exterior surface of said reactor is selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

7. The cavitation nuclear reactor of claim 1, further comprising a heater, wherein said heater preheats said reactor prior to reactor operation.

8. The cavitation nuclear reactor of claim 1, further comprising a heater, wherein during at least a portion of reactor operation said heater heats said reactor promoting formation of said cavities.

9. The cavitation nuclear reactor of claim 8, wherein said heater is a resistive heater substantially enclosing said reactor.

10. The cavitation nuclear reactor of claim 8, wherein said heater is a directed heat source.

11. The cavitation nuclear reactor of claim 10, wherein said directed heat source is a laser.

12. The cavitation nuclear reactor of claim 10, wherein said directed heat source is an inductive heater.

13. The cavitation nuclear reactor of claim 10, wherein said directed heat source is a microwave heater.

14. The cavitation nuclear reactor of claim 1, said reactor further comprising:

a host material; and

a fuel material, said fuel material interspersed within said host material.

15. The cavitation nuclear reactor of claim 14, wherein a first melting temperature associated with said host material is greater than a second melting temperature associated with said fuel material.

16. The cavitation nuclear reactor of claim 14, wherein a melting temperature associated with said host material is greater than a vaporization temperature associated with said fuel material.

17. The cavitation nuclear reactor of claim 14, wherein said host material is a metal.

18. The cavitation nuclear reactor of claim 14, wherein said host material is selected from the group of materials consisting of titanium, tungsten, gadolinium, cadmium, molybdenum, rhenium, osmium, hafnium, iridium, niobium, ruthenium, and tantalum.

19. The cavitation nuclear reactor of claim 1, wherein said frequency is between about 1 kHz and about 20 GHz.

20. The cavitation nuclear reactor of claim 1, wherein said frequency is between about 50 kHz and about 400 kHz.

21. The cavitation nuclear reactor of claim 1, wherein said frequency source outputs a plurality of frequencies, wherein at least one of said plurality of frequencies is substantially an integer multiple of said at least one resonant frequency.

22. The cavitation nuclear reactor of claim 21, further comprising means for periodically altering said frequency within said plurality of frequencies.

23. The cavitation nuclear reactor of claim 22, wherein said frequency is altered by less than ± 10 % of said frequency.

24. The cavitation nuclear reactor of claim 1, wherein said at least one acoustic driver is comprised of at least one magnetostrictive device.

25. The cavitation nuclear reactor of claim 1, wherein said at least one acoustic driver is comprised of at least one piezo-electric crystal.

26. The cavitation nuclear reactor of claim 25, wherein said at least one acoustic driver is further comprised of a resonator mass.

27. The cavitation nuclear reactor of claim 25, wherein said at least one acoustic driver is further comprised of a pair of resonator masses.

28. The cavitation nuclear reactor of claim 25, wherein said at least one acoustic driver is further comprised of a pair of complimentary coupling members, wherein a first of said pair of complimentary coupling members is attached to said reactor and a second of said pair of complimentary coupling members is attached to said at least one acoustic driver.

29. The cavitation nuclear reactor of claim 1, wherein said at least one acoustic driver is comprised of at least one projectile discharge system.

30. The cavitation nuclear reactor of claim 1, wherein said at least one acoustic driver is comprised of at least one pulsed liquid jet generator.

31. The cavitation nuclear reactor of claim 1, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location substantially coincident with a reactor displacement node.

32. The cavitation nuclear reactor of claim 1, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location undergoing minimal reactor displacement during operation.

33. The cavitation nuclear reactor of claim 1, wherein said plurality of nuclear reactions are fusion reactions.

34. The cavitation nuclear reactor of claim 33, wherein at least one material undergoing said fusion reactions is selected from the group of materials consisting of deuterium, tritium, and lithium.

35. The cavitation nuclear reactor of claim 34, wherein said at least one material undergoing said fusion reactions is interspersed within a host material.

36. The cavitation nuclear reactor of claim 35, wherein said host material is selected from the group of materials consisting of titanium and tungsten.

37. The cavitation nuclear reactor of claim 1, wherein said plurality of nuclear reactions are fission reactions.

38. The cavitation nuclear reactor of claim 1, wherein said plurality of nuclear reactions are spallation reactions.

39. The cavitation nuclear reactor of claim 1, wherein said plurality of nuclear reactions are neutron stripping reactions.

40. The cavitation nuclear reactor of claim 39, wherein said neutron stripping reactions occur between a heavy isotope and a light isotope.

41. The cavitation nuclear reactor of claim 40, wherein said heavy isotope is a radioactive isotope.

42. The cavitation nuclear reactor of claim 40, wherein said heavy isotope is selected from the group of heavy isotopes consisting of gadolinium, cadmium, europium, boron, samarium, dysprosium, iridium, and mercury.

43. The cavitation nuclear reactor of claim 40, wherein said light isotope is selected from the group of light isotopes consisting of deuterium, tritium, and lithium.

44. The cavitation nuclear reactor of claim 40, wherein said heavy isotope has a large thermal neutron capture cross-section.

45. The cavitation nuclear reactor of claim 44, wherein said large thermal neutron capture cross-section is greater than 10 barns.

46. A cavitation nuclear reactor, comprising:

a reactor, wherein during operation said reactor is comprised of a solid material interspersed by a plurality of cavitation bubbles, wherein said reactor has at least one resonant frequency;

a frequency source outputting a frequency that is substantially a non-integer multiple of said at least one resonant frequency; and

at least one acoustic driver coupled to said reactor at at least one location, said at least one acoustic driver coupled to said frequency source and driving acoustic

energy of said substantially non-integer multiple of said at least one resonant frequency into said reactor, wherein said acoustic energy, said at least one location, and a plurality of reactor characteristics define a pressure intensity pattern within said reactor, wherein said plurality of cavitation bubbles occur at a portion of a plurality of pressure intensity anti-nodes defined by said pressure intensity pattern, wherein said plurality of cavitation bubbles undergo at least one complete cavitation cycle comprising a period of bubble expansion and a period of bubble collapse, and wherein a plurality of nuclear reactions occur within a portion of said plurality of cavitation bubbles during said cavitation cycle.

47. The cavitation nuclear reactor of claim 46, wherein said frequency is greater than said at least one resonant frequency.

48. The cavitation nuclear reactor of claim 46, wherein said plurality of reactor characteristics include shape, size, material, mechanical history, and thermal history of said reactor.

49. The cavitation nuclear reactor of claim 46, wherein said plurality of cavitation bubbles are between about 0.1 micrometers and about 100 micrometers in diameter.

50. The cavitation nuclear reactor of claim 46, wherein a shape corresponding to an exterior surface of said reactor is selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

51. The cavitation nuclear reactor of claim 46, further comprising a heater, wherein said heater preheats said reactor prior to reactor operation.

52. The cavitation nuclear reactor of claim 46, further comprising a heater, wherein during at least a portion of reactor operation said heater heats said reactor promoting formation of said cavities.

53. The cavitation nuclear reactor of claim 52, wherein said heater is a resistive heater substantially enclosing said reactor.

54. The cavitation nuclear reactor of claim 52, wherein said heater is a directed heat source.

55. The cavitation nuclear reactor of claim 54, wherein said directed heat source is a laser.

56. The cavitation nuclear reactor of claim 54, wherein said directed heat source is an inductive heater.

57. The cavitation nuclear reactor of claim 54, wherein said directed heat source is a microwave heater.

58. The cavitation nuclear reactor of claim 46, said reactor further comprising:

a host material; and

a fuel material, said fuel material interspersed within said host material.

59. The cavitation nuclear reactor of claim 58, wherein a first melting temperature associated with said host material is greater than a second melting temperature associated with said fuel material.

60. The cavitation nuclear reactor of claim 58, wherein a melting temperature associated with said host material is greater than a vaporization temperature associated with said fuel material.

61. The cavitation nuclear reactor of claim 58, wherein said host material is a metal.

62. The cavitation nuclear reactor of claim 58, wherein said host material is selected from the group of materials consisting of titanium, tungsten, gadolinium, cadmium, molybdenum, rhenium, osmium, hafnium, iridium, niobium, ruthenium, and tantalum.

63. The cavitation nuclear reactor of claim 46, wherein said frequency is between about 1 kHz and about 20 GHz.

64. The cavitation nuclear reactor of claim 46, wherein said frequency is between about 50 kHz and about 400 kHz.

65. The cavitation nuclear reactor of claim 46, further comprising means for periodically altering said frequency within a range of frequencies.

66. The cavitation nuclear reactor of claim 65, wherein said frequency is altered by less than ± 10 % of said frequency.

67. The cavitation nuclear reactor of claim 46, wherein said at least one acoustic driver is comprised of at least one magnetostrictive device.

68. The cavitation nuclear reactor of claim 46, wherein said at least one acoustic driver is comprised of at least one piezo-electric crystal.

69. The cavitation nuclear reactor of claim 68, wherein said at least one acoustic driver is further comprised of a resonator mass.

70. The cavitation nuclear reactor of claim 68, wherein said at least one acoustic driver is further comprised of a pair of resonator masses.

71. The cavitation nuclear reactor of claim 68, wherein said at least one acoustic driver is further comprised of a pair of complimentary coupling members, wherein a first of said pair of complimentary coupling members is attached to said reactor and a second of said pair of complimentary coupling members is attached to said at least one acoustic driver.

72. The cavitation nuclear reactor of claim 46, wherein said at least one acoustic driver is comprised of at least one projectile discharge system.

73. The cavitation nuclear reactor of claim 46, wherein said at least one acoustic driver is comprised of at least one pulsed liquid jet generator.

74. The cavitation nuclear reactor of claim 46, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location substantially coincident with a reactor displacement node.

75. The cavitation nuclear reactor of claim 46, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location undergoing minimal reactor displacement during operation.

76. The cavitation nuclear reactor of claim 46, wherein said plurality of nuclear reactions are fusion reactions.

77. The cavitation nuclear reactor of claim 76, wherein at least one material undergoing said fusion reactions is selected from the group of materials consisting of deuterium, tritium, and lithium.

78. The cavitation nuclear reactor of claim 77, wherein said at least one material undergoing said fusion reactions is interspersed within a host material.

79. The cavitation nuclear reactor of claim 78, wherein said host material is selected from the group of materials consisting of titanium and tungsten.

80. The cavitation nuclear reactor of claim 46, wherein said plurality of nuclear reactions are fission reactions.

81. The cavitation nuclear reactor of claim 46, wherein said plurality of nuclear reactions are spallation reactions.

82. The cavitation nuclear reactor of claim 46, wherein said plurality of nuclear reactions are neutron stripping reactions.

83. The cavitation nuclear reactor of claim 82, wherein said neutron stripping reactions occur between a heavy isotope and a light isotope.

84. The cavitation nuclear reactor of claim 83, wherein said heavy isotope is a radioactive isotope.

85. The cavitation nuclear reactor of claim 83, wherein said heavy isotope is selected from the group of heavy isotopes consisting of gadolinium, cadmium, europium, boron, samarium, dysprosium, iridium, and mercury.

86. The cavitation nuclear reactor of claim 83, wherein said light isotope is selected from the group of light isotopes consisting of deuterium, tritium, and lithium.

87. The cavitation nuclear reactor of claim 83, wherein said heavy isotope has a large thermal neutron capture cross-section.

88. The cavitation nuclear reactor of claim 87, wherein said large thermal neutron capture cross-section is greater than 10 barns.

89. A cavitation nuclear reactor, comprising:

a reactor, wherein during operation said reactor is comprised of a solid material interspersed by a plurality of cavitation bubbles;

a frequency source outputting a frequency; and

at least one acoustic driver coupled to said reactor and to said frequency source, said at least one acoustic driver driving acoustic energy into said reactor to form a pressure density pattern comprising a plurality of pressure intensity anti-nodes, wherein said plurality of cavitation bubbles form at a portion of said plurality of pressure intensity anti-nodes, wherein said plurality of cavitation bubbles undergo at least one complete cavitation cycle comprising a period of bubble expansion and a period of bubble collapse, and wherein a plurality of nuclear reactions occur within a portion of said plurality of cavitation bubbles during said cavitation cycle.

90. The cavitation nuclear reactor of claim 89, wherein said pressure density pattern includes a density gradient.

91. The cavitation nuclear reactor of claim 90, wherein said density gradient varies from high density near a center portion of said reactor to low density near an exterior surface of said reactor.

92. The cavitation nuclear reactor of claim 89, wherein said frequency is between about 1 kHz and about 20 GHz.

93. The cavitation nuclear reactor of claim 89, wherein said frequency is between about 50 kHz and about 400 kHz.

94. The cavitation nuclear reactor of claim 89, wherein said reactor has at least one resonant frequency, and wherein said frequency is of substantially an integer multiple of said at least one resonant frequency.

95. The cavitation nuclear reactor of claim 89, wherein said reactor has at least one resonant frequency, wherein said frequency source outputs a plurality of

frequencies, and wherein at least one of said plurality of frequencies is substantially an integer multiple of said at least one resonant frequency.

96. The cavitation nuclear reactor of claim 95, further comprising means for periodically altering said frequency within said plurality of frequencies.

97. The cavitation nuclear reactor of claim 96, wherein said frequency is altered by less than ± 10 % of said frequency.

98. The cavitation nuclear reactor of claim 89, wherein said reactor has at least one resonant frequency, and wherein said frequency is of substantially a non-integer multiple of said at least one resonant frequency.

99. The cavitation nuclear reactor of claim 98, further comprising means for periodically altering said frequency within a range of frequencies.

100. The cavitation nuclear reactor of claim 99, wherein said frequency is altered by less than ± 10 % of said frequency.

101. The cavitation nuclear reactor of claim 89, wherein said plurality of cavitation bubbles are between about 0.1 micrometers and about 100 micrometers in diameter.

102. The cavitation nuclear reactor of claim 89, wherein a shape corresponding to said exterior surface of said reactor is selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

103. The cavitation nuclear reactor of claim 89, further comprising a heater, wherein said heater preheats said reactor prior to reactor operation.

104. The cavitation nuclear reactor of claim 89, further comprising a heater, wherein during at least a portion of reactor operation said heater heats said reactor promoting formation of said cavities.

105. The cavitation nuclear reactor of claim 104, wherein said heater is a resistive heater substantially enclosing said reactor.

106. The cavitation nuclear reactor of claim 104, wherein said heater is a directed heat source.

107. The cavitation nuclear reactor of claim 106, wherein said directed heat source is a laser.

108. The cavitation nuclear reactor of claim 106, wherein said directed heat source is an inductive heater.

109. The cavitation nuclear reactor of claim 106, wherein said directed heat source is a microwave heater.

110. The cavitation nuclear reactor of claim 89, said reactor further comprising:

a host material; and

a fuel material, said fuel material interspersed within said host material.

111. The cavitation nuclear reactor of claim 110, wherein a first melting temperature associated with said host material is greater than a second melting temperature associated with said fuel material.

112. The cavitation nuclear reactor of claim 110, wherein a melting temperature associated with said host material is greater than a vaporization temperature associated with said fuel material.

113. The cavitation nuclear reactor of claim 110, wherein said host material is a metal.

114. The cavitation nuclear reactor of claim 110, wherein said host material is selected from the group of materials consisting of titanium, tungsten, gadolinium, cadmium, molybdenum, rhenium, osmium, hafnium, iridium, niobium, ruthenium, and tantalum.

115. The cavitation nuclear reactor of claim 89, wherein said at least one acoustic driver is comprised of at least one magnetostrictive device.

116. The cavitation nuclear reactor of claim 89, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one piezo-electric crystal.

117. The cavitation nuclear reactor of claim 116, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a resonator mass.

118. The cavitation nuclear reactor of claim 116, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a pair of resonator masses.

119. The cavitation nuclear reactor of claim 116, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a pair of complimentary coupling members, wherein a first of said pair of complimentary coupling members is attached to said reactor and a second of said pair of complimentary coupling members is attached to said at least one acoustic driver.

120. The cavitation nuclear reactor of claim 89, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one projectile discharge system.

121. The cavitation nuclear reactor of claim 89, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one pulsed liquid jet generator.

122. The cavitation nuclear reactor of claim 89, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location substantially coincident with a reactor displacement node.

123. The cavitation nuclear reactor of claim 89, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location undergoing minimal reactor displacement during operation.

124. The cavitation nuclear reactor of claim 89, wherein said plurality of nuclear reactions are fusion reactions.

125. The cavitation nuclear reactor of claim 124, wherein at least one material undergoing said fusion reactions is selected from the group of materials consisting of deuterium, tritium, and lithium.

126. The cavitation nuclear reactor of claim 125, wherein said at least one material undergoing said fusion reactions is interspersed within a host material.

127. The cavitation nuclear reactor of claim 126, wherein said host material is selected from the group of materials consisting of titanium and tungsten.

128. The cavitation nuclear reactor of claim 89, wherein said plurality of nuclear reactions are fission reactions.

129. The cavitation nuclear reactor of claim 89, wherein said plurality of nuclear reactions are spallation reactions.

130. The cavitation nuclear reactor of claim 89, wherein said plurality of nuclear reactions are neutron stripping reactions.

131. The cavitation nuclear reactor of claim 130, wherein said neutron stripping reactions occur between a heavy isotope and a light isotope.

132. The cavitation nuclear reactor of claim 131, wherein said heavy isotope is a radioactive isotope.

133. The cavitation nuclear reactor of claim 131, wherein said heavy isotope is selected from the group of heavy isotopes consisting of gadolinium, cadmium, europium, boron, samarium, dysprosium, iridium, and mercury.

134. The cavitation nuclear reactor of claim 131, wherein said light isotope is selected from the group of light isotopes consisting of deuterium, tritium, and lithium.

135. The cavitation nuclear reactor of claim 131, wherein said heavy isotope has a large thermal neutron capture cross-section.

136. The cavitation nuclear reactor of claim 135, wherein said large thermal neutron capture cross-section is greater than 10 barns.

137. A cavitation nuclear reactor, comprising:

a reactor, wherein during operation said reactor is comprised of a solid material interspersed by a plurality of cavitation bubbles, wherein said reactor is further comprised of a plurality of host material of a first acoustic impedance and a plurality of fuel material of a second acoustic impedance;

a frequency source outputting a frequency; and

at least one acoustic driver coupled to said reactor and to said frequency source, said at least one acoustic driver driving acoustic energy into said reactor to form said plurality of cavitation bubbles within a portion of said plurality of fuel material, wherein said plurality of cavitation bubbles undergo at least one complete cavitation cycle comprising a period of bubble expansion and a period of bubble collapse, and wherein a plurality of nuclear reactions occur within a portion of said plurality of cavitation bubbles during said cavitation cycle.

138. The cavitation nuclear reactor of claim 137, wherein said plurality of host material is comprised of a plurality of host powder particles, and wherein said plurality of fuel material is comprised of a plurality of fuel powder particles.

139. The cavitation nuclear reactor of claim 137, wherein said first acoustic impedance is higher than said second acoustic impedance.

140. The cavitation nuclear reactor of claim 137, wherein said plurality of fuel material is interspersed throughout said plurality of host material in a predetermined pattern.

141. The cavitation nuclear reactor of claim 140, wherein said predetermined pattern is a gradient pattern.

142. The cavitation nuclear reactor of claim 137, wherein a density of said plurality of fuel material is highest at a substantially center location of said reactor.

143. The cavitation nuclear reactor of claim 137, wherein said frequency is between about 1 kHz and about 20 GHz.

144. The cavitation nuclear reactor of claim 137, wherein said frequency is between about 50 kHz and about 400 kHz.

145. The cavitation nuclear reactor of claim 137, wherein said reactor has at least one resonant frequency, and wherein said frequency is of substantially an integer multiple of said at least one resonant frequency.

146. The cavitation nuclear reactor of claim 137, wherein said reactor has at least one resonant frequency, wherein said frequency source outputs a plurality of frequencies, and wherein at least one of said plurality of frequencies is substantially an integer multiple of said at least one resonant frequency.

147. The cavitation nuclear reactor of claim 146, further comprising means for periodically altering said frequency within said plurality of frequencies.

148. The cavitation nuclear reactor of claim 147, wherein said frequency is altered by less than ± 10 % of said frequency.

149. The cavitation nuclear reactor of claim 137, wherein said reactor has at least one resonant frequency, and wherein said frequency is of substantially a non-integer multiple of said at least one resonant frequency.

150. The cavitation nuclear reactor of claim 149, further comprising means for periodically altering said frequency within a range of frequencies.

151. The cavitation nuclear reactor of claim 150, wherein said frequency is altered by less than ± 10 % of said frequency.

152. The cavitation nuclear reactor of claim 137, wherein said plurality of cavitation bubbles are between about 0.1 micrometers and about 100 micrometers in diameter.

153. The cavitation nuclear reactor of claim 137, wherein a shape corresponding to said exterior surface of said reactor is selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

154. The cavitation nuclear reactor of claim 137, further comprising a heater, wherein said heater preheats said reactor prior to reactor operation.

155. The cavitation nuclear reactor of claim 137, further comprising a heater, wherein during at least a portion of reactor operation said heater heats said reactor promoting formation of said cavities.

156. The cavitation nuclear reactor of claim 155, wherein said heater is a resistive heater substantially enclosing said reactor.

157. The cavitation nuclear reactor of claim 155, wherein said heater is a directed heat source.

158. The cavitation nuclear reactor of claim 157, wherein said directed heat source is a laser.

159. The cavitation nuclear reactor of claim 157, wherein said directed heat source is an inductive heater.

160. The cavitation nuclear reactor of claim 157, wherein said directed heat source is a microwave heater.

161. The cavitation nuclear reactor of claim 137, wherein a first melting temperature associated with said host material is greater than a second melting temperature associated with said fuel material.

162. The cavitation nuclear reactor of claim 137, wherein a melting temperature associated with said host material is greater than a vaporization temperature associated with said fuel material.

163. The cavitation nuclear reactor of claim 137, wherein said host material is a metal.

164. The cavitation nuclear reactor of claim 137, wherein said host material is selected from the group of materials consisting of titanium, tungsten, gadolinium, cadmium, molybdenum, rhenium, osmium, hafnium, iridium, niobium, ruthenium, and tantalum.

165. The cavitation nuclear reactor of claim 137, wherein said at least one acoustic driver is comprised of at least one magnetostrictive device.

166. The cavitation nuclear reactor of claim 137, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one piezo-electric crystal.

167. The cavitation nuclear reactor of claim 166, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a resonator mass.

168. The cavitation nuclear reactor of claim 166, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a pair of resonator masses.

169. The cavitation nuclear reactor of claim 166, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a pair of complimentary coupling members, wherein a first of said pair of complimentary coupling members is attached to said reactor and a second of said pair of complimentary coupling members is attached to said at least one acoustic driver.

170. The cavitation nuclear reactor of claim 137, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one projectile discharge system.

171. The cavitation nuclear reactor of claim 137, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one pulsed liquid jet generator.

172. The cavitation nuclear reactor of claim 137, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location substantially coincident with a reactor displacement node.

173. The cavitation nuclear reactor of claim 137, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location undergoing minimal reactor displacement during operation.

174. The cavitation nuclear reactor of claim 137, wherein said plurality of nuclear reactions are fusion reactions.

175. The cavitation nuclear reactor of claim 137, wherein said plurality of nuclear reactions are fusion reactions, and wherein at least one material comprising said plurality of fuel material is selected from the group of materials consisting of deuterium, tritium, and lithium.

176. The cavitation nuclear reactor of claim 137, wherein said plurality of nuclear reactions are fission reactions.

177. The cavitation nuclear reactor of claim 137, wherein said plurality of nuclear reactions are spallation reactions.

178. The cavitation nuclear reactor of claim 137, wherein said plurality of nuclear reactions are neutron stripping reactions.

179. The cavitation nuclear reactor of claim 178, wherein said neutron stripping reactions occur between a heavy isotope and a light isotope.

180. The cavitation nuclear reactor of claim 179, wherein said heavy isotope is a radioactive isotope.

181. The cavitation nuclear reactor of claim 179, wherein said heavy isotope is selected from the group of heavy isotopes consisting of gadolinium, cadmium, europium, boron, samarium, dysprosium, iridium, and mercury.

182. The cavitation nuclear reactor of claim 179, wherein said light isotope is selected from the group of light isotopes consisting of deuterium, tritium, and lithium.

183. The cavitation nuclear reactor of claim 179, wherein said heavy isotope has a large thermal neutron capture cross-section.

184. The cavitation nuclear reactor of claim 183, wherein said large thermal neutron capture cross-section is greater than 10 barns.

185. A cavitation nuclear reactor, comprising:

a reactor, wherein during operation said reactor is comprised of a solid material interspersed by a plurality of cavitation bubbles;

a first frequency source outputting a first frequency;

at least one acoustic driver coupled to said first frequency source and to said reactor driving acoustic energy of said first frequency into said reactor;

a second frequency source outputting a second frequency; and

at least one acoustic driver coupled to said second frequency source and to said reactor driving acoustic energy of said second frequency into said reactor, wherein said acoustic energy of said first frequency and said acoustic energy of said second frequency define a pressure intensity pattern within said reactor, wherein said plurality of cavitation bubbles occur at a portion of a plurality of pressure intensity anti-nodes defined by said pressure intensity pattern, wherein said plurality of cavitation bubbles undergo at least one complete cavitation cycle comprising a period of bubble expansion and a period of bubble collapse, and wherein a plurality of nuclear reactions occur within a portion of said plurality of cavitation bubbles during said cavitation cycle.

186. The cavitation nuclear reactor of claim 185, wherein said at least one acoustic driver coupled to said first frequency source is a microwave driver.

187. The cavitation nuclear reactor of claim 185, wherein said first frequency is between about 50 kHz and about 400 kHz and wherein said second frequency is between about 50 kHz and about 400 kHz.

188. The cavitation nuclear reactor of claim 185, wherein said first frequency is between about 50 kHz and about 400 kHz and wherein said second frequency is between about 1 MHz and about 20 GHz.

189. The cavitation nuclear reactor of claim 185, wherein said reactor has at least one resonant frequency, and wherein said first frequency is of substantially an integer multiple of said at least one resonant frequency.

190. The cavitation nuclear reactor of claim 185, wherein said reactor has at least one resonant frequency, wherein said first frequency source outputs a plurality of frequencies, and wherein at least one of said plurality of frequencies is substantially an integer multiple of said at least one resonant frequency.

191. The cavitation nuclear reactor of claim 190, further comprising means for periodically altering said first frequency within said plurality of frequencies.

192. The cavitation nuclear reactor of claim 191, wherein said first frequency is altered by less than ± 10 % of said frequency.

193. The cavitation nuclear reactor of claim 185, wherein said reactor has at least one resonant frequency, and wherein said first frequency is of substantially a non-integer multiple of said at least one resonant frequency.

194. The cavitation nuclear reactor of claim 193, further comprising means for periodically altering said first frequency within a range of frequencies.

195. The cavitation nuclear reactor of claim 194, wherein said first frequency is altered by less than ± 10 % of said frequency.

196. The cavitation nuclear reactor of claim 185, wherein said reactor has at least one resonant frequency, wherein said first frequency is of substantially an integer multiple of said at least one resonant frequency, and wherein said second frequency is of substantially a non-integer multiple of said at least one resonant frequency.

197. The cavitation nuclear reactor of claim 185, wherein said plurality of cavitation bubbles are between about 0.1 micrometers and about 100 micrometers in diameter.

198. The cavitation nuclear reactor of claim 185, wherein a shape corresponding to an exterior surface of said reactor is selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

199. The cavitation nuclear reactor of claim 185, further comprising a heater, wherein said heater preheats said reactor prior to reactor operation.

200. The cavitation nuclear reactor of claim 185, further comprising a heater, wherein during at least a portion of reactor operation said heater heats said reactor promoting formation of said cavities.

201. The cavitation nuclear reactor of claim 200, wherein said heater is a resistive heater substantially enclosing said reactor.

202. The cavitation nuclear reactor of claim 200, wherein said heater is a directed heat source.

203. The cavitation nuclear reactor of claim 202, wherein said directed heat source is a laser.

204. The cavitation nuclear reactor of claim 202, wherein said directed heat source is an inductive heater.

205. The cavitation nuclear reactor of claim 202, wherein said directed heat source is a microwave heater.

206. The cavitation nuclear reactor of claim 185, said reactor further comprising:

a host material; and

a fuel material, said fuel material interspersed within said host material.

207. The cavitation nuclear reactor of claim 206, wherein a first melting temperature associated with said host material is greater than a second melting temperature associated with said fuel material.

208. The cavitation nuclear reactor of claim 206, wherein a melting temperature associated with said host material is greater than a vaporization temperature associated with said fuel material.

209. The cavitation nuclear reactor of claim 206, wherein said host material is a metal.

210. The cavitation nuclear reactor of claim 206, wherein said host material is selected from the group of materials consisting of titanium, tungsten, gadolinium, cadmium, molybdenum, rhenium, osmium, hafnium, iridium, niobium, ruthenium, and tantalum.

211. The cavitation nuclear reactor of claim 185, wherein said at least one acoustic driver is comprised of at least one magnetostrictive device.

212. The cavitation nuclear reactor of claim 185, wherein said at least one acoustic driver coupled to said first frequency source is comprised of at least one piezo-electric crystal.

213. The cavitation nuclear reactor of claim 212, wherein said at least one acoustic driver coupled to said first frequency source is further comprised of a resonator mass.

214. The cavitation nuclear reactor of claim 212, wherein said at least one acoustic driver coupled to said first frequency source is further comprised of a pair of resonator masses.

215. The cavitation nuclear reactor of claim 212, wherein said at least one acoustic driver coupled to said first frequency source is further comprised of a pair of complimentary coupling members, wherein a first of said pair of complimentary coupling members is attached to said reactor and a second of said pair of complimentary coupling members is attached to said at least one acoustic driver.

216. The cavitation nuclear reactor of claim 185, wherein said at least one acoustic driver coupled to said first frequency source is comprised of at least one projectile discharge system.

217. The cavitation nuclear reactor of claim 185, wherein said at least one acoustic driver coupled to said first frequency source is comprised of at least one pulsed liquid jet generator.

218. The cavitation nuclear reactor of claim 185, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location substantially coincident with a reactor displacement node.

219. The cavitation nuclear reactor of claim 185, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location undergoing minimal reactor displacement during operation.

220. The cavitation nuclear reactor of claim 185, wherein said plurality of nuclear reactions are fusion reactions.

221. The cavitation nuclear reactor of claim 220, wherein at least one material undergoing said fusion reactions is selected from the group of materials consisting of deuterium, tritium, and lithium.

222. The cavitation nuclear reactor of claim 221, wherein said at least one material undergoing said fusion reactions is interspersed within a host material.

223. The cavitation nuclear reactor of claim 222, wherein said host material is selected from the group of materials consisting of titanium and tungsten.

224. The cavitation nuclear reactor of claim 185, wherein said plurality of nuclear reactions are fission reactions.

225. The cavitation nuclear reactor of claim 185, wherein said plurality of nuclear reactions are spallation reactions.

226. The cavitation nuclear reactor of claim 185, wherein said plurality of nuclear reactions are neutron stripping reactions.

227. The cavitation nuclear reactor of claim 226, wherein said neutron stripping reactions occur between a heavy isotope and a light isotope.

228. The cavitation nuclear reactor of claim 227, wherein said heavy isotope is a radioactive isotope.

229. The cavitation nuclear reactor of claim 227, wherein said heavy isotope is selected from the group of heavy isotopes consisting of gadolinium, cadmium, europium, boron, samarium, dysprosium, iridium, and mercury.

230. The cavitation nuclear reactor of claim 227, wherein said light isotope is selected from the group of light isotopes consisting of deuterium, tritium, and lithium.

231. The cavitation nuclear reactor of claim 227, wherein said heavy isotope has a large thermal neutron capture cross-section.

232. The cavitation nuclear reactor of claim 231, wherein said large thermal neutron capture cross-section is greater than 10 barns.

233. A cavitation nuclear reactor, comprising:

a reactor, wherein during operation said reactor is comprised of a solid material interspersed by a plurality of cavitation bubbles;

a frequency source outputting a frequency;

at least one acoustic driver coupled to said reactor at at least one location, said at least one acoustic driver coupled to said frequency source and driving acoustic energy into said reactor, wherein said acoustic energy, said at least one location, and a plurality of reactor characteristics define a pressure intensity pattern within said reactor, wherein said plurality of cavitation bubbles occur at a portion of a plurality of pressure intensity anti-nodes defined by said pressure intensity pattern, wherein said plurality of cavitation bubbles undergo at least one complete cavitation cycle comprising a period of bubble expansion and a period of bubble collapse, and wherein a plurality of nuclear reactions occur within a portion of said plurality of cavitation bubbles during said cavitation cycle; and

a coolant system comprising a coolant in contact with an exterior surface of said reactor.

234. The cavitation nuclear reactor of claim 233, said coolant system further comprising a coolant jacket substantially enclosing said reactor, wherein at least a portion of said coolant is contained within said coolant jacket.

235. The cavitation nuclear reactor of claim 234, said coolant system further comprising:

a coolant reservoir coupled to said coolant jacket; and

a coolant pump coupled to said coolant jacket and to said coolant reservoir.

236. The cavitation nuclear reactor of claim 234, further comprising a heat exchanger coupled to said coolant system.

237. The cavitation nuclear reactor of claim 234, further comprising a steam turbine coupled to said coolant system.

238. The cavitation nuclear reactor of claim 234, further comprising an electrical generator coupled to said coolant system.

239. The cavitation nuclear reactor of claim 234, further comprising a magneto-hydrodynamic generator, wherein said coolant is a liquid metal.

240. The cavitation nuclear reactor of claim 234, wherein said frequency is between about 1 kHz and about 20 GHz.

241. The cavitation nuclear reactor of claim 234, wherein said frequency is between about 50 kHz and about 400 kHz.

242. The cavitation nuclear reactor of claim 234, wherein said reactor has at least one resonant frequency, and wherein said frequency is of substantially an integer multiple of said at least one resonant frequency.

243. The cavitation nuclear reactor of claim 234, wherein said reactor has at least one resonant frequency, wherein said frequency source outputs a plurality of frequencies, and wherein at least one of said plurality of frequencies is substantially an integer multiple of said at least one resonant frequency.

244. The cavitation nuclear reactor of claim 243, further comprising means for periodically altering said frequency within said plurality of frequencies.

245. The cavitation nuclear reactor of claim 244, wherein said frequency is altered by less than ± 10 % of said frequency.

246. The cavitation nuclear reactor of claim 234, wherein said reactor has at least one resonant frequency, and wherein said frequency is of substantially a non-integer multiple of said at least one resonant frequency.

247. The cavitation nuclear reactor of claim 246, further comprising means for periodically altering said frequency within a range of frequencies.

248. The cavitation nuclear reactor of claim 247, wherein said frequency is altered by less than ± 10 % of said frequency.

249. The cavitation nuclear reactor of claim 234, wherein said plurality of cavitation bubbles are between about 0.1 micrometers and about 100 micrometers in diameter.

250. The cavitation nuclear reactor of claim 234, wherein a shape corresponding to said exterior surface of said reactor is selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

251. The cavitation nuclear reactor of claim 234, further comprising a heater, wherein said heater preheats said reactor prior to reactor operation.

252. The cavitation nuclear reactor of claim 234, further comprising a heater, wherein during at least a portion of reactor operation said heater heats said reactor promoting formation of said cavities.

253. The cavitation nuclear reactor of claim 252, wherein said heater is a directed heat source.

254. The cavitation nuclear reactor of claim 253, wherein said directed heat source is a laser.

255. The cavitation nuclear reactor of claim 253, wherein said directed heat source is an inductive heater.

256. The cavitation nuclear reactor of claim 253, wherein said directed heat source is a microwave heater.

257. The cavitation nuclear reactor of claim 234, said reactor further comprising:

a host material; and

a fuel material, said fuel material interspersed within said host material.

258. The cavitation nuclear reactor of claim 257, wherein a first melting temperature associated with said host material is greater than a second melting temperature associated with said fuel material.

259. The cavitation nuclear reactor of claim 257, wherein a melting temperature associated with said host material is greater than a vaporization temperature associated with said fuel material.

260. The cavitation nuclear reactor of claim 257, wherein said host material is a metal.

261. The cavitation nuclear reactor of claim 257, wherein said host material is selected from the group of materials consisting of titanium, tungsten, gadolinium, cadmium, molybdenum, rhenium, osmium, hafnium, iridium, niobium, ruthenium, and tantalum.

262. The cavitation nuclear reactor of claim 234, wherein said at least one acoustic driver is comprised of at least one magnetostrictive device.

263. The cavitation nuclear reactor of claim 234, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one piezo-electric crystal.

264. The cavitation nuclear reactor of claim 263, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a resonator mass.

265. The cavitation nuclear reactor of claim 263, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a pair of resonator masses.

266. The cavitation nuclear reactor of claim 263, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a pair of complimentary coupling members, wherein a first of said pair of complimentary coupling members is attached to said reactor and a second of said pair of complimentary coupling members is attached to said at least one acoustic driver.

267. The cavitation nuclear reactor of claim 234, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one projectile discharge system.

268. The cavitation nuclear reactor of claim 234, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one pulsed liquid jet generator.

269. The cavitation nuclear reactor of claim 234, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location substantially coincident with a reactor displacement node.

270. The cavitation nuclear reactor of claim 234, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location undergoing minimal reactor displacement during operation.

271. The cavitation nuclear reactor of claim 234, wherein said plurality of nuclear reactions are fusion reactions.

272. The cavitation nuclear reactor of claim 271, wherein at least one material undergoing said fusion reactions is selected from the group of materials consisting of deuterium, tritium, and lithium.

273. The cavitation nuclear reactor of claim 272, wherein said at least one material undergoing said fusion reactions is interspersed within a host material.

274. The cavitation nuclear reactor of claim 273, wherein said host material is selected from the group of materials consisting of titanium and tungsten.

275. The cavitation nuclear reactor of claim 234, wherein said plurality of nuclear reactions are fission reactions.

276. The cavitation nuclear reactor of claim 234, wherein said plurality of nuclear reactions are spallation reactions.

277. The cavitation nuclear reactor of claim 234, wherein said plurality of nuclear reactions are neutron stripping reactions.

278. The cavitation nuclear reactor of claim 277, wherein said neutron stripping reactions occur between a heavy isotope and a light isotope.

279. The cavitation nuclear reactor of claim 278, wherein said heavy isotope is a radioactive isotope.

280. The cavitation nuclear reactor of claim 278, wherein said heavy isotope is selected from the group of heavy isotopes consisting of gadolinium, cadmium, europium, boron, samarium, dysprosium, iridium, and mercury.

281. The cavitation nuclear reactor of claim 278, wherein said light isotope is selected from the group of light isotopes consisting of deuterium, tritium, and lithium.

282. The cavitation nuclear reactor of claim 278, wherein said heavy isotope has a large thermal neutron capture cross-section.

283. The cavitation nuclear reactor of claim 282, wherein said large thermal neutron capture cross-section is greater than 10 barns.

284. A cavitation nuclear reactor, comprising:

a reactor, wherein during operation said reactor is comprised of a solid material interspersed by a plurality of cavitation bubbles, and wherein said reactor includes at least one interior coolant passageway;

a frequency source outputting a frequency;

at least one acoustic driver coupled to said reactor at at least one location, said at least one acoustic driver coupled to said frequency source and driving acoustic energy into said reactor, wherein said acoustic energy, said at least one location, and a plurality of reactor characteristics define a pressure intensity pattern within said reactor, wherein said plurality of cavitation bubbles occur at a portion of a plurality of pressure intensity anti-nodes defined by said pressure intensity pattern, wherein said plurality of cavitation bubbles undergo at least one complete cavitation cycle comprising a period of bubble expansion and a period of bubble collapse, and wherein a plurality of nuclear reactions occur within a portion of said plurality of cavitation bubbles during said cavitation cycle; and

a coolant system comprising a coolant in contact with an exterior surface of said reactor and with an interior surface of said reactor as defined by said at least one interior passageway.

285. The cavitation nuclear reactor of claim 284, said coolant system further comprising a coolant jacket substantially enclosing said reactor, wherein at least a portion of said coolant is contained within said coolant jacket.

286. The cavitation nuclear reactor of claim 285, said coolant system further comprising:

a coolant reservoir coupled to said coolant jacket; and

a coolant pump coupled to said coolant jacket and to said coolant reservoir.

287. The cavitation nuclear reactor of claim 285, further comprising a heat exchanger coupled to said coolant system.

288. The cavitation nuclear reactor of claim 285, further comprising a steam turbine coupled to said coolant system.

289. The cavitation nuclear reactor of claim 285, further comprising an electrical generator coupled to said coolant system.

290. The cavitation nuclear reactor of claim 285, further comprising a magneto-hydrodynamic generator, wherein said coolant is a liquid metal.

291. The cavitation nuclear reactor of claim 285, wherein said frequency is between about 1 kHz and about 20 GHz.

292. The cavitation nuclear reactor of claim 285, wherein said frequency is between about 50 kHz and about 400 kHz.

293. The cavitation nuclear reactor of claim 285, wherein said reactor has at least one resonant frequency, and wherein said frequency is of substantially an integer multiple of said at least one resonant frequency.

294. The cavitation nuclear reactor of claim 285, wherein said reactor has at least one resonant frequency, wherein said frequency source outputs a plurality of frequencies, and wherein at least one of said plurality of frequencies is substantially an integer multiple of said at least one resonant frequency.

295. The cavitation nuclear reactor of claim 294, further comprising means for periodically altering said frequency within said plurality of frequencies.

296. The cavitation nuclear reactor of claim 295, wherein said frequency is altered by less than ± 10 % of said frequency.

297. The cavitation nuclear reactor of claim 285, wherein said reactor has at least one resonant frequency, and wherein said frequency is of substantially a non-integer multiple of said at least one resonant frequency.

298. The cavitation nuclear reactor of claim 297, further comprising means for periodically altering said frequency within a range of frequencies.

299. The cavitation nuclear reactor of claim 298, wherein said frequency is altered by less than ± 10 % of said frequency.

300. The cavitation nuclear reactor of claim 285, wherein said plurality of cavitation bubbles are between about 0.1 micrometers and about 100 micrometers in diameter.

301. The cavitation nuclear reactor of claim 285, wherein a shape corresponding to said exterior surface of said reactor is selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

302. The cavitation nuclear reactor of claim 285, further comprising a heater, wherein said heater preheats said reactor prior to reactor operation.

303. The cavitation nuclear reactor of claim 285, further comprising a heater, wherein during at least a portion of reactor operation said heater heats said reactor promoting formation of said cavities.

304. The cavitation nuclear reactor of claim 303, wherein said heater is a directed heat source.

305. The cavitation nuclear reactor of claim 304, wherein said directed heat source is a laser.

306. The cavitation nuclear reactor of claim 304, wherein said directed heat source is an inductive heater.

307. The cavitation nuclear reactor of claim 304, wherein said directed heat source is a microwave heater.

308. The cavitation nuclear reactor of claim 285, said reactor further comprising:

a host material; and

a fuel material, said fuel material interspersed within said host material.

309. The cavitation nuclear reactor of claim 308, wherein a first melting temperature associated with said host material is greater than a second melting temperature associated with said fuel material.

310. The cavitation nuclear reactor of claim 308, wherein a melting temperature associated with said host material is greater than a vaporization temperature associated with said fuel material.

311. The cavitation nuclear reactor of claim 308, wherein said host material is a metal.

312. The cavitation nuclear reactor of claim 308, wherein said host material is selected from the group of materials consisting of titanium, tungsten, gadolinium, cadmium, molybdenum, rhenium, osmium, hafnium, iridium, niobium, ruthenium, and tantalum.

313. The cavitation nuclear reactor of claim 285, wherein said at least one acoustic driver is comprised of at least one magnetostrictive device.

314. The cavitation nuclear reactor of claim 285, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one piezo-electric crystal.

315. The cavitation nuclear reactor of claim 314, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a resonator mass.

316. The cavitation nuclear reactor of claim 314, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a pair of resonator masses.

317. The cavitation nuclear reactor of claim 314, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a pair of complimentary coupling members, wherein a first of said pair of complimentary coupling members is attached to said reactor and a second of said pair of complimentary coupling members is attached to said at least one acoustic driver.

318. The cavitation nuclear reactor of claim 285, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one projectile discharge system.

319. The cavitation nuclear reactor of claim 285, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one pulsed liquid jet generator.

320. The cavitation nuclear reactor of claim 285, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location substantially coincident with a reactor displacement node.

321. The cavitation nuclear reactor of claim 285, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location undergoing minimal reactor displacement during operation.

322. The cavitation nuclear reactor of claim 285, wherein said plurality of nuclear reactions are fusion reactions.

323. The cavitation nuclear reactor of claim 322, wherein at least one material undergoing said fusion reactions is selected from the group of materials consisting of deuterium, tritium, and lithium.

324. The cavitation nuclear reactor of claim 323, wherein said at least one material undergoing said fusion reactions is interspersed within a host material.

325. The cavitation nuclear reactor of claim 324, wherein said host material is selected from the group of materials consisting of titanium and tungsten.

326. The cavitation nuclear reactor of claim 285, wherein said plurality of nuclear reactions are fission reactions.

327. The cavitation nuclear reactor of claim 285, wherein said plurality of nuclear reactions are spallation reactions.

328. The cavitation nuclear reactor of claim 285, wherein said plurality of nuclear reactions are neutron stripping reactions.

329. The cavitation nuclear reactor of claim 328, wherein said neutron stripping reactions occur between a heavy isotope and a light isotope.

330. The cavitation nuclear reactor of claim 329, wherein said heavy isotope is a radioactive isotope.

331. The cavitation nuclear reactor of claim 329, wherein said heavy isotope is selected from the group of heavy isotopes consisting of gadolinium, cadmium, europium, boron, samarium, dysprosium, iridium, and mercury.

332. The cavitation nuclear reactor of claim 329, wherein said light isotope is selected from the group of light isotopes consisting of deuterium, tritium, and lithium.

333. The cavitation nuclear reactor of claim 329, wherein said heavy isotope has a large thermal neutron capture cross-section.

334. The cavitation nuclear reactor of claim 333, wherein said large thermal neutron capture cross-section is greater than 10 barns.

335. A cavitation nuclear reactor, comprising:

a reactor, wherein during operation said reactor is comprised of a solid material interspersed by a plurality of cavitation bubbles, said reactor having a single topological handle;

a frequency source outputting a frequency;

at least one acoustic driver coupled to said reactor at at least one location, said at least one acoustic driver coupled to said frequency source and driving acoustic energy into said reactor, wherein said acoustic energy, said at least one location, and a plurality of reactor characteristics define a pressure intensity pattern within said reactor, wherein said plurality of cavitation bubbles occur at a portion of a plurality of pressure intensity anti-nodes defined by said pressure intensity pattern, wherein said cavitation bubbles undergo at least one expansion and collapse cycle, and wherein a plurality of nuclear reactions occur within a portion of said plurality of said cavitation bubbles during said expansion and collapse cycle; and

a coolant system comprising a coolant jacket substantially enclosing said reactor, and a coolant contained within said coolant jacket, said coolant in contact with an exterior surface of said reactor and with an interior surface of said reactor as defined by said single topological handle.

336. A cavitation nuclear reactor, comprising:

a reactor, wherein during operation said reactor is comprised of a solid material interspersed by a plurality of cavitation bubbles, said reactor having a plurality of topological handles;

a frequency source outputting a frequency;

at least one acoustic driver coupled to said reactor at at least one location, said at least one acoustic driver coupled to said frequency source and driving acoustic energy into said reactor, wherein said acoustic energy, said at least one location, and a plurality of reactor characteristics define a pressure intensity pattern within said reactor, wherein said plurality of cavitation bubbles occur at a portion of a plurality of pressure intensity anti-nodes defined by said pressure intensity pattern, wherein said cavitation bubbles undergo at least one expansion and collapse cycle, and wherein a plurality of nuclear reactions occur within a portion of said plurality of said cavitation bubbles during said expansion and collapse cycle; and

a coolant system comprising a coolant jacket substantially enclosing said reactor, and a coolant contained within said coolant jacket, said coolant in contact with an

exterior surface of said reactor and with an interior surface of said reactor as defined by said plurality of topological handles.

337. A cavitation nuclear reactor, comprising:

a reactor, wherein during operation said reactor is comprised of a solid material interspersed by a plurality of cavitation bubbles, wherein said reactor is further comprised of an inner core region and an outer shell surrounding said inner core region;

a frequency source outputting a frequency; and

at least one acoustic driver coupled to said reactor and to said frequency source, said at least one acoustic driver driving acoustic energy into said reactor to form said plurality of cavitation bubbles within a portion of said inner core region, wherein said plurality of cavitation bubbles undergo at least one complete cavitation cycle comprising a period of bubble expansion and a period of bubble collapse, and wherein a plurality of nuclear reactions occur within a portion of said plurality of cavitation bubbles during said cavitation cycle.

338. The cavitation nuclear reactor of claim 337, wherein said inner core region is of a first acoustic impedance and said outer shell is of a second acoustic impedance.

339. The cavitation nuclear reactor of claim 338, wherein said first acoustic impedance is lower than said second acoustic impedance.

340. The cavitation nuclear reactor of claim 337, wherein a shape corresponding to an exterior surface of said outer shell is selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

341. The cavitation nuclear reactor of claim 337, wherein a shape corresponding to said inner core is selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

342. The cavitation nuclear reactor of claim 337, wherein said frequency is between about 1 kHz and about 20 GHz.

343. The cavitation nuclear reactor of claim 337, wherein said frequency is between about 50 kHz and about 400 kHz.

344. The cavitation nuclear reactor of claim 337, wherein said reactor has at least one resonant frequency, and wherein said frequency is of substantially an integer multiple of said at least one resonant frequency.

345. The cavitation nuclear reactor of claim 337, wherein said reactor has at least one resonant frequency, wherein said frequency source outputs a plurality of frequencies, and wherein at least one of said plurality of frequencies is substantially an integer multiple of said at least one resonant frequency.

346. The cavitation nuclear reactor of claim 345, further comprising means for periodically altering said frequency within said plurality of frequencies.

347. The cavitation nuclear reactor of claim 346, wherein said frequency is altered by less than ± 10 % of said frequency.

348. The cavitation nuclear reactor of claim 337, wherein said reactor has at least one resonant frequency, and wherein said frequency is of substantially a non-integer multiple of said at least one resonant frequency.

349. The cavitation nuclear reactor of claim 348, further comprising means for periodically altering said frequency within a range of frequencies.

350. The cavitation nuclear reactor of claim 348, wherein said frequency is altered by less than ± 10 % of said frequency.

351. The cavitation nuclear reactor of claim 337, wherein said plurality of cavitation bubbles are between about 0.1 micrometers and about 100 micrometers in diameter.

352. The cavitation nuclear reactor of claim 337, further comprising a heater, wherein said heater preheats said reactor prior to reactor operation.

353. The cavitation nuclear reactor of claim 337, further comprising a heater, wherein during at least a portion of reactor operation said heater heats said reactor promoting formation of said cavities.

354. The cavitation nuclear reactor of claim 353, wherein said heater is a resistive heater substantially enclosing said reactor.

355. The cavitation nuclear reactor of claim 353, wherein said heater is a directed heat source.

356. The cavitation nuclear reactor of claim 355, wherein said directed heat source is a laser.

357. The cavitation nuclear reactor of claim 355, wherein said directed heat source is an inductive heater.

358. The cavitation nuclear reactor of claim 355, wherein said directed heat source is a microwave heater.

359. The cavitation nuclear reactor of claim 337, wherein said outer shell is a metal.

360. The cavitation nuclear reactor of claim 337, wherein said outer shell is selected from the group of materials consisting of titanium, tungsten, and gadolinium.

361. The cavitation nuclear reactor of claim 337, wherein said at least one acoustic driver is comprised of at least one magnetostrictive device.

362. The cavitation nuclear reactor of claim 337, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one piezo-electric crystal.

363. The cavitation nuclear reactor of claim 362, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a resonator mass.

364. The cavitation nuclear reactor of claim 362, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a pair of resonator masses.

365. The cavitation nuclear reactor of claim 362, wherein said at least one acoustic driver coupled to said frequency source is further comprised of a pair of complimentary coupling members, wherein a first of said pair of complimentary coupling members is attached to said reactor and a second of said pair of complimentary coupling members is attached to said at least one acoustic driver.

366. The cavitation nuclear reactor of claim 337, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one projectile discharge system.

367. The cavitation nuclear reactor of claim 337, wherein said at least one acoustic driver coupled to said frequency source is comprised of at least one pulsed liquid jet generator.

368. The cavitation nuclear reactor of claim 337, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location substantially coincident with a reactor displacement node.

369. The cavitation nuclear reactor of claim 337, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location undergoing minimal reactor displacement during operation.

370. The cavitation nuclear reactor of claim 337, wherein said plurality of nuclear reactions are fusion reactions.

371. The cavitation nuclear reactor of claim 337, wherein at least one material comprising said inner core is selected from the group of materials consisting of deuterium, tritium, and lithium.

372. The cavitation nuclear reactor of claim 337, wherein said plurality of nuclear reactions are fission reactions.

373. The cavitation nuclear reactor of claim 337, wherein said plurality of nuclear reactions are spallation reactions.

374. The cavitation nuclear reactor of claim 337, wherein said plurality of nuclear reactions are neutron stripping reactions.

375. The cavitation nuclear reactor of claim 374, wherein said neutron stripping reactions occur between a heavy isotope and a light isotope.

376. The cavitation nuclear reactor of claim 375, wherein said heavy isotope is a radioactive isotope.

377. The cavitation nuclear reactor of claim 375, wherein said heavy isotope is selected from the group of heavy isotopes consisting of gadolinium, cadmium, europium, boron, samarium, dysprosium, iridium, and mercury.

378. The cavitation nuclear reactor of claim 375, wherein said light isotope is selected from the group of light isotopes consisting of deuterium, tritium, and lithium.

379. The cavitation nuclear reactor of claim 375, wherein said heavy isotope has a large thermal neutron capture cross-section.

380. The cavitation nuclear reactor of claim 379, wherein said large thermal neutron capture cross-section is greater than 10 barns.

381. A cavitation nuclear reactor, comprising:

a reactor, wherein during operation said reactor is comprised of a solid material interspersed by a plurality of cavitation bubbles, wherein said reactor is further comprised of a plurality of fuel particles interspersed within a plurality of host particles; and

a microwave source emitting microwave energy with a frequency, said microwave energy forming said plurality of cavitation bubbles within a portion of said plurality of fuel particles, wherein said plurality of cavitation bubbles undergo at least one complete cavitation cycle comprising a period of bubble expansion and a period of bubble collapse, and wherein a plurality of nuclear reactions occur within a portion of said plurality of cavitation bubbles during said cavitation cycle.

382. The cavitation nuclear reactor of claim 381, wherein said frequency is between about 1 MHz and 20 GHz.

383. The cavitation nuclear reactor of claim 381, wherein said microwave source simultaneously emits a plurality of frequencies.

384. The cavitation nuclear reactor of claim 381, wherein an acoustic wavelength corresponding to said frequency of said microwave energy is substantially equivalent to an average particle size of said plurality of fuel particles.

385. The cavitation nuclear reactor of claim 381, wherein an acoustic wavelength corresponding to said frequency of said microwave energy is substantially equivalent to an average particle spacing of said plurality of fuel particles within said plurality of host particles.

386. The cavitation nuclear reactor of claim 381, wherein a density of said plurality of fuel particles is highest at a substantially center location of said reactor.

387. The cavitation nuclear reactor of claim 381, wherein said plurality of fuel particles are comprised of GdD_2.

388. The cavitation nuclear reactor of claim 381, wherein an average particle size of said plurality of fuel particles is between about 0.1 and about 100 micrometers.

389. The cavitation nuclear reactor of claim 388, wherein an average particle size of said plurality of fuel particles is 5 micrometers.

390. The cavitation nuclear reactor of claim 381, wherein a first melting temperature associated with said plurality of host particles is greater than a second melting temperature associated with said plurality of fuel particles.

391. The cavitation nuclear reactor of claim 381, wherein a melting temperature associated with said plurality of host particles is greater than a vaporization temperature associated with said plurality of fuel particles.

392. The cavitation nuclear reactor of claim 381, wherein said plurality of host particles are selected from the group of materials consisting of titanium, tungsten, gadolinium, cadmium, molybdenum, rhenium, osmium, hafnium, iridium, niobium, ruthenium, and tantalum.

393. The cavitation nuclear reactor of claim 381, wherein an average particle spacing of said plurality of fuel particles is between about 10 and about 1000 micrometers.

394. The cavitation nuclear reactor of claim 393, wherein an average particle spacing of said plurality of fuel particles is 50 micrometers.

395. The cavitation nuclear reactor of claim 381, wherein an exterior surface of said reactor adjacent to said microwave source includes at least one surface depression, said at least one surface depression improving penetration of said microwave energy into said reactor.

396. The cavitation nuclear reactor of claim 381, wherein said plurality of cavitation bubbles are between about 0.1 micrometers and about 100 micrometers in diameter.

397. The cavitation nuclear reactor of claim 381, wherein a shape corresponding to an exterior surface of said reactor is selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

398. The cavitation nuclear reactor of claim 381, further comprising a heater, wherein said heater preheats said reactor prior to reactor operation.

399. The cavitation nuclear reactor of claim 381, further comprising a heater, wherein during at least a portion of reactor operation said heater heats said reactor promoting formation of said cavities.

400. The cavitation nuclear reactor of claim 399, wherein said heater is a resistive heater substantially enclosing said reactor.

401. The cavitation nuclear reactor of claim 399, wherein said heater is a directed heat source.

402. The cavitation nuclear reactor of claim 401, wherein said directed heat source is a laser.

403. The cavitation nuclear reactor of claim 401, wherein said directed heat source is an inductive heater.

404. The cavitation nuclear reactor of claim 401, wherein said directed heat source is a microwave heater.

405. The cavitation nuclear reactor of claim 381, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location substantially coincident with a reactor displacement node.

406. The cavitation nuclear reactor of claim 381, further comprising at least one reactor support member, said at least one reactor support member attached to said reactor at a location undergoing minimal reactor displacement during operation.

407. The cavitation nuclear reactor of claim 381, wherein said plurality of nuclear reactions are fusion reactions.

408. The cavitation nuclear reactor of claim 381, wherein said plurality of nuclear reactions are fusion reactions, and wherein at least one material comprising said plurality of fuel particles is selected from the group of materials consisting of deuterium, tritium, and lithium.

409. The cavitation nuclear reactor of claim 381, wherein said plurality of nuclear reactions are fission reactions.

410. The cavitation nuclear reactor of claim 381, wherein said plurality of nuclear reactions are spallation reactions.

411. The cavitation nuclear reactor of claim 381, wherein said plurality of nuclear reactions are neutron stripping reactions.

412. The cavitation nuclear reactor of claim 411, wherein said neutron stripping reactions occur between a heavy isotope and a light isotope.

413. The cavitation nuclear reactor of claim 412, wherein said heavy isotope is a radioactive isotope.

414. The cavitation nuclear reactor of claim 412, wherein said heavy isotope is selected from the group of heavy isotopes consisting of gadolinium, cadmium, europium, boron, samarium, dysprosium, iridium, and mercury.

415. The cavitation nuclear reactor of claim 412, wherein said light isotope is selected from the group of light isotopes consisting of deuterium, tritium, and lithium.

416. The cavitation nuclear reactor of claim 412, wherein said heavy isotope has a large thermal neutron capture cross-section.

417. The cavitation nuclear reactor of claim 416, wherein said large thermal neutron capture cross-section is greater than 10 barns.

418. A cavitation nuclear reactor, comprising:

a reactor, wherein during operation said reactor is comprised of a solid material interspersed by a plurality of cavitation bubbles;

a plurality of liquid jet generators, wherein each of said liquid jet generators emits a stream of liquid directed at a location on an exterior surface of said reactor, wherein said plurality of liquid streams emitted by said plurality of liquid jet generators supports said reactor during operation; and

means for pulsing said plurality of liquid jet generators to form a plurality of liquid streams of time varying mass, said plurality of liquid streams driving acoustic energy into said reactor to form a pressure intensity pattern within said reactor, wherein said plurality of cavitation bubbles occur at a portion of a plurality of pressure intensity anti-nodes defined by said pressure intensity pattern, wherein said plurality of cavitation bubbles undergo at least one complete cavitation cycle comprising a period of bubble expansion and a period of bubble collapse, and wherein a plurality of nuclear reactions occur within a portion of said plurality of cavitation bubbles during said cavitation cycle.

419. The cavitation nuclear reactor of claim 418, wherein said plurality of liquid streams of time varying mass are comprised of a plurality of liquid droplets.

420. The cavitation nuclear reactor of claim 418, wherein said plurality of liquid streams of time varying mass are comprised of a plurality of continuous liquid streams.

421. The cavitation nuclear reactor of claim 418, said plurality of liquid jet generators comprised of three liquid jet generators.

422. The cavitation nuclear reactor of claim 418, said plurality of liquid jet generators comprised of four liquid jet generators, wherein at least one of said plurality of liquid streams is downwardly directed.

423. The cavitation nuclear reactor of claim 418, further comprising at least one temporary reactor support member.

424. The cavitation nuclear reactor of claim 418, wherein said liquid is water.

425. The cavitation nuclear reactor of claim 418, further comprising a coolant system comprising a coolant reservoir coupled to said plurality of liquid jet generators, wherein said liquid is a coolant.

426. The cavitation nuclear reactor of claim 425, further comprising a heat exchanger coupled to said coolant system.

427. The cavitation nuclear reactor of claim 425, further comprising a steam turbine coupled to said coolant system.

428. The cavitation nuclear reactor of claim 425, further comprising an electrical generator coupled to said coolant system.

429. The cavitation nuclear reactor of claim 425, further comprising a magneto-hydrodynamic generator, wherein said coolant is a liquid metal.

430. The cavitation nuclear reactor of claim 418, wherein said pulsing means further comprises an ultrasonically excited needle assembly within each of said plurality of liquid jet generators.

431. The cavitation nuclear reactor of claim 418, wherein said pulsing means further comprises an acoustic modulator coupled to each of said plurality of liquid jet generators.

432. The cavitation nuclear reactor of claim 418, wherein a frequency corresponding to a pulse rate of said pulsing means is between about 1 kHz and about 10 MHz.

433. The cavitation nuclear reactor of claim 418, wherein a frequency corresponding to a pulse rate of said pulsing means is between about 50 kHz and about 400 kHz.

434. The cavitation nuclear reactor of claim 418, wherein said reactor has at least one resonant frequency, and wherein a frequency corresponding to a pulse rate of said pulsing means is of substantially an integer multiple of said at least one resonant frequency.

435. The cavitation nuclear reactor of claim 418, wherein said reactor has at least one resonant frequency, wherein said pulsing means outputs a plurality of pulse rates corresponding to a plurality of frequencies, and wherein at least one of said plurality of frequencies is substantially an integer multiple of said at least one resonant frequency.

436. The cavitation nuclear reactor of claim 435, further comprising means for periodically altering said pulse rate within said plurality of pulse rates.

437. The cavitation nuclear reactor of claim 436, wherein said pulse rate is altered by less than ± 10 % of said frequency.

438. The cavitation nuclear reactor of claim 418, wherein said reactor has at least one resonant frequency, and wherein a frequency corresponding to a pulse rate of said pulsing means is of substantially a non-integer multiple of said at least one resonant frequency.

439. The cavitation nuclear reactor of claim 438, further comprising means for periodically altering said pulse rate within a range of pulse rates.

440. The cavitation nuclear reactor of claim 439, wherein said pulse rate is altered by less than ± 10 % of said frequency.

441. The cavitation nuclear reactor of claim 418, wherein said plurality of cavitation bubbles are between about 0.1 micrometers and about 100 micrometers in diameter.

442. The cavitation nuclear reactor of claim 418, wherein a shape corresponding to said exterior surface of said reactor is selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

443. The cavitation nuclear reactor of claim 418, further comprising a heater, wherein said heater preheats said reactor prior to reactor operation.

444. The cavitation nuclear reactor of claim 418, further comprising a heater, wherein during at least a portion of reactor operation said heater heats said reactor promoting formation of said cavities.

445. The cavitation nuclear reactor of claim 444, wherein said heater is a directed heat source.

446. The cavitation nuclear reactor of claim 445, wherein said directed heat source is a laser.

447. The cavitation nuclear reactor of claim 445, wherein said directed heat source is an inductive heater.

448. The cavitation nuclear reactor of claim 445, wherein said directed heat source is a microwave heater.

449. The cavitation nuclear reactor of claim 418, said reactor further comprising:

a host material; and

a fuel material, said fuel material interspersed within said host material.

450. The cavitation nuclear reactor of claim 449, wherein a first melting temperature associated with said host material is greater than a second melting temperature associated with said fuel material.

451. The cavitation nuclear reactor of claim 449, wherein a melting temperature associated with said host material is greater than a vaporization temperature associated with said fuel material.

452. The cavitation nuclear reactor of claim 449, wherein said host material is a metal.

453. The cavitation nuclear reactor of claim 449, wherein said host material is selected from the group of materials consisting of titanium, tungsten, gadolinium, cadmium, molybdenum, rhenium, osmium, hafnium, iridium, niobium, ruthenium, and tantalum.

454. The cavitation nuclear reactor of claim 418, wherein said plurality of nuclear reactions are fusion reactions.

455. The cavitation nuclear reactor of claim 454, wherein at least one material undergoing said fusion reactions is selected from the group of materials consisting of deuterium, tritium, and lithium.

456. The cavitation nuclear reactor of claim 455, wherein said at least one material undergoing said fusion reactions is interspersed within a host material.

457. The cavitation nuclear reactor of claim 455, wherein said host material is selected from the group of materials consisting of titanium and tungsten.

458. The cavitation nuclear reactor of claim 418, wherein said plurality of nuclear reactions are fission reactions.

459. The cavitation nuclear reactor of claim 418, wherein said plurality of nuclear reactions are spallation reactions.

460. The cavitation nuclear reactor of claim 418, wherein said plurality of nuclear reactions are neutron stripping reactions.

461. The cavitation nuclear reactor of claim 460, wherein said neutron stripping reactions occur between a heavy isotope and a light isotope.

462. The cavitation nuclear reactor of claim 461, wherein said heavy isotope is a radioactive isotope.

463. The cavitation nuclear reactor of claim 461, wherein said heavy isotope is selected from the group of heavy isotopes consisting of gadolinium, cadmium, europium, boron, samarium, dysprosium, iridium, and mercury.

464. The cavitation nuclear reactor of claim 461, wherein said light isotope is selected from the group of light isotopes consisting of deuterium, tritium, and lithium.

465. The cavitation nuclear reactor of claim 461, wherein said heavy isotope has a large thermal neutron capture cross-section.

466. The cavitation nuclear reactor of claim 465, wherein said large thermal neutron capture cross-section is greater than 10 barns.

467. A method of operating a nuclear reactor, the method comprising the steps of:

coupling at least one acoustic driver to said nuclear reactor, wherein said nuclear reactor is comprised of solid material;

coupling a frequency source to said at least one acoustic driver;

outputting a frequency by said frequency source;

driving acoustic energy of said frequency into said nuclear reactor with said at least one acoustic driver;

forming a pressure intensity pattern within said nuclear reactor, wherein said pressure intensity pattern defines a plurality of pressure intensity anti-nodes;

forming a plurality of cavitation bubbles within said nuclear reactor at a portion of said plurality of pressure intensity anti-nodes;

expanding said plurality of cavitation bubbles at least once; and

collapsing said plurality of expanded cavitation bubbles at least once, wherein a density and a temperature associated with a portion of said plurality of collapsing cavitation bubbles is sufficient to drive a nuclear reaction.

468. The method of claim 467, wherein spherically converging material corresponding to said plurality of collapsing cavitation bubbles attains supersonic velocities.

469. The method of claim 467, said frequency outputting step further comprising the step of outputting said frequency at a substantially integer multiple of at least one resonant frequency of said nuclear reactor.

470. The method of claim 467, further comprising the step of periodically altering said frequency output by said frequency source from among a plurality of frequencies, wherein at least one of said plurality of frequencies is substantially an integer multiple of at least one resonant frequency of said nuclear reactor.

471. The method of claim 471, wherein said periodic altering steps alters said frequency output by less than ± 10 % of said frequency.

472. The method of claim 467, said frequency outputting step further comprising the step of outputting said frequency at a substantially non-integer multiple of at least one resonant frequency of said nuclear reactor.

473. The method of claim 473, wherein said frequency outputting step further comprises the step of periodically altering said frequency output.

474. The method of claim 473, wherein said periodic altering steps alters said frequency output by less than ± 10 % of said frequency.

475. The method of claim 467, further comprising the step of forming said nuclear reactor into a shape selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

476. The method of claim 467, further comprising the step of preheating said nuclear reactor prior to said driving step.

477. The method of claim 467, further comprising the step of heating said nuclear reactor, wherein said heating step is performed simultaneously with said driving step.

478. The method of claim 467, further comprising the step of directing a heat source at said nuclear reactor prior to said driving step.

479. The method of claim 467, further comprising the step of directing a heat source at said nuclear reactor, wherein said directing step is performed simultaneously with said driving step.

480. The method of claim 467, further comprising the step of forming said nuclear reactor from a host material and a fuel material.

481. The method of claim 467, further comprising the step of forming said nuclear reactor from a host material with a first melting temperature and a fuel material with a second melting temperature, wherein said first melting temperature is greater than said second melting temperature.

482. The method of claim 467, further comprising the step of forming said nuclear reactor from a host material with a melting temperature and a fuel material with a vaporization temperature, wherein said melting temperature is greater than said vaporization temperature.

483. The method of claim 467, further comprising the step of forming said nuclear reactor from a host material and a fuel material, wherein said host material is selected from the group of materials consisting of gadolinium, titanium, and tungsten.

484. The method of claim 467, further comprising the step of forming said nuclear reactor from a host material and a fuel material, wherein said fuel material is selected from the group of materials selected from deuterium, tritium, and lithium.

485. The method of claim 467, further comprising the step of forming said nuclear reactor from a host material and a fuel material.

486. The method of claim 485, further comprising the step of interspersing said fuel material throughout said host material in a predetermined pattern.

487. The method of claim 485, further comprising the step of interspersing said fuel material throughout said host material wherein a density of said fuel material is highest at a substantially center location of said nuclear reactor.

488. The method of claim 467, further comprising the steps of:
mixing a powder of a fuel material with a powder of a host material;
compressing said mixed powders into a structure of a predetermined nuclear reactor shape; and
sintering said compressed structure.

489. The method of claim 488, wherein said mixing step further comprises the step of mixing said fuel material powder and said host material powder according to a predetermined concentration pattern.

490. The method of claim 488, wherein said sintering step is performed in a deuterium furnace.

491. The method of claim 488, further comprising the step of heating said sintered, compressed structure.

492. The method of claim 491, wherein said heating step is performed within a vacuum furnace.

493. The method of claim 491, wherein said heating step is performed within a high pressure inert gas furnace.

494. The method of claim 493, wherein said inert gas furnace is an argon furnace.

495. The method of claim 467, further comprising the steps of:
heating a host material in a furnace;
exposing said host material to a high pressure gas of a reactant during said heating step to load said host material with said reactant; and
machining said loaded host material into a predetermined nuclear reactor shape.

496. The method of claim 495, further comprising the step of heating said machined, loaded host material.

497. The method of claim 496, wherein said heating step is performed within a vacuum furnace.

498. The method of claim 496, wherein said heating step is performed within a high pressure inert gas furnace.

499. The method of claim 498, wherein said inert gas furnace is an argon furnace.

500. The method of claim 467, further comprising the steps of:

melting a host material;

bubbling a reactant through said melted host material to load said host material with said reactant; and

forming said loaded host material into a predetermined nuclear reactor shape.

501. The method of claim 500, wherein said forming step further comprises casting said loaded host material into an intermediate reactor shape.

502. The method of claim 501, said method further comprising the step of machining said intermediate reactor shape into said predetermined nuclear reactor shape.

503. The method of claim 500, wherein said forming step comprises casting said loaded host material into said predetermined nuclear reactor shape.

504. The method of claim 500, further comprising the step of heating said predetermined nuclear reactor shape.

505. The method of claim 504, wherein said heating step is performed within a vacuum furnace.

506. The method of claim 504, wherein said heating step is performed within a high pressure inert gas furnace.

507. The method of claim 506, wherein said inert gas furnace is an argon furnace.

508. The method of claim 467, wherein said nuclear reaction is a fusion reaction.

509. The method of claim 467, wherein said nuclear reaction is a fission reaction.

510. The method of claim 467, wherein said nuclear reaction is a spallation reaction.

511. The method of claim 467, wherein said nuclear reaction is a neutron stripping reaction.

512. The method of claim 467, further comprising the step of forming said nuclear reactor from a plurality of materials, said plurality of materials comprising a heavy isotope and a light isotope, wherein said heavy isotope is selected from the group of heavy isotopes consisting of gadolinium, cadmium, europium, boron, samarium, dysprosium, iridium, and mercury, wherein said light isotope is selected from the group of light isotopes consisting of deuterium, tritium, and lithium, and wherein said nuclear reaction is a neutron stripping reaction.

513. The method of claim 467, further comprising the steps of:

selecting a heavy isotope from a group of isotopes exhibiting large thermal neutron capture cross-sections; and

forming said nuclear reactor from a plurality of materials, said plurality of materials comprising said selected heavy isotope and a light isotope.

514. The method of claim 467, further comprising the step of cooling an exterior surface of said nuclear reactor.

515. The method of claim 467, further comprising the steps of:

directing a coolant at at least a portion of an exterior surface of said nuclear reactor, wherein said coolant is heated by said nuclear reactor; and

withdrawing said heated coolant.

516. The method of claim 515, further comprising the step of circulating said coolant through a circulation system.

517. The method of claim 515, further comprising the step of passing said heated coolant through a heat exchanger.

518. The method of claim 515, further comprising the step of directing said heated coolant through a steam turbine.

519. The method of claim 515, further comprising the step of directing said heated coolant through an electrical generator.

520. The method of claim 515, further comprising the step of directing said coolant through at least one interior coolant passageway of said nuclear reactor.

521. A method of radioactive waste remediation, the method comprising the steps of:

forming a cavitation nuclear reactor from said radioactive waste, wherein said formed cavitation nuclear reactor is comprised of solid phase material;

coupling at least one acoustic driver to said cavitation nuclear reactor;

coupling a frequency source to said at least one acoustic driver;

outputting a frequency by said frequency source;

driving acoustic energy of said frequency into said cavitation nuclear reactor with said at least one acoustic driver;

forming a pressure intensity pattern within said cavitation nuclear reactor, wherein said pressure intensity pattern defines a plurality of pressure intensity anti-nodes;

forming a plurality of cavitation bubbles within said cavitation nuclear reactor at a portion of said plurality of pressure intensity anti-nodes;

expanding said plurality of cavitation bubbles at least once; and

collapsing said plurality of expanded cavitation bubbles at least once, wherein a density and a temperature associated with a portion of said plurality of collapsing cavitation bubbles is sufficient to drive a remediation reaction.

522. The method of claim 521, wherein said remediation reaction is a fission reaction.

523. The method of claim 521, wherein said remediation reaction is a spallation reaction.

524. The method of claim 521, further comprising the step of loading said formed cavitation nuclear reactor with deuterium.

525. The method of claim 524, wherein said remediation reaction is a neutron stripping reaction.

526. The method of claim 521, wherein spherically converging material corresponding to said plurality of collapsing cavitation bubbles attains supersonic velocities.

527. The method of claim 521, said frequency outputting step further comprising the step of outputting said frequency at a substantially integer multiple of at least one resonant frequency of said cavitation nuclear reactor.

528. The method of claim 521, further comprising the step of periodically altering said frequency output by said frequency source from among a plurality of frequencies, wherein at least one of said plurality of frequencies is substantially an integer multiple of at least one resonant frequency of said cavitation nuclear reactor.

529. The method of claim 528, wherein said periodic altering steps alters said frequency output by less than ± 10 % of said frequency.

530. The method of claim 521, said frequency outputting step further comprising the step of outputting said frequency at a substantially non-integer multiple of at least one resonant frequency of said cavitation nuclear reactor.

531. The method of claim 530, wherein said frequency outputting step further comprises the step of periodically altering said frequency output.

532. The method of claim 531, wherein said periodic altering steps alters said frequency output by less than ± 10 % of said frequency.

533. The method of claim 521, wherein said forming step further comprises the step of forming said cavitation nuclear reactor into a shape selected from the group of shapes consisting of spherical, cylindrical, conical, cubic, rectangular, and irregular.

534. The method of claim 521, further comprising the step of preheating said cavitation nuclear reactor prior to said driving step.

535. The method of claim 521, further comprising the step of heating said cavitation nuclear reactor, wherein said heating step is performed simultaneously with said driving step.

536. The method of claim 521, further comprising the step of directing a heat source at said cavitation nuclear reactor prior to said driving step.

537. The method of claim 521, further comprising the step of directing a heat source at said cavitation nuclear reactor, wherein said directing step is performed simultaneously with said driving step.

538. The method of claim 521, further comprising the step of cooling an exterior surface of said cavitation nuclear reactor.

539. The method of claim 521, further comprising the steps of:

directing a coolant at at least a portion of an exterior surface of said cavitation nuclear reactor, wherein said coolant is heated by said cavitation nuclear reactor; and

withdrawing said heated coolant.

540. The method of claim 539, further comprising the step of circulating said coolant through a circulation system.

541. The method of claim 539, further comprising the step of passing said heated coolant through a heat exchanger.

542. The method of claim 539, further comprising the step of directing said heated coolant through a steam turbine.

543. The method of claim 539, further comprising the step of directing said heated coolant through an electrical generator.

544. The method of claim 539, further comprising the step of directing said coolant through at least one interior coolant passageway of said nuclear reactor.

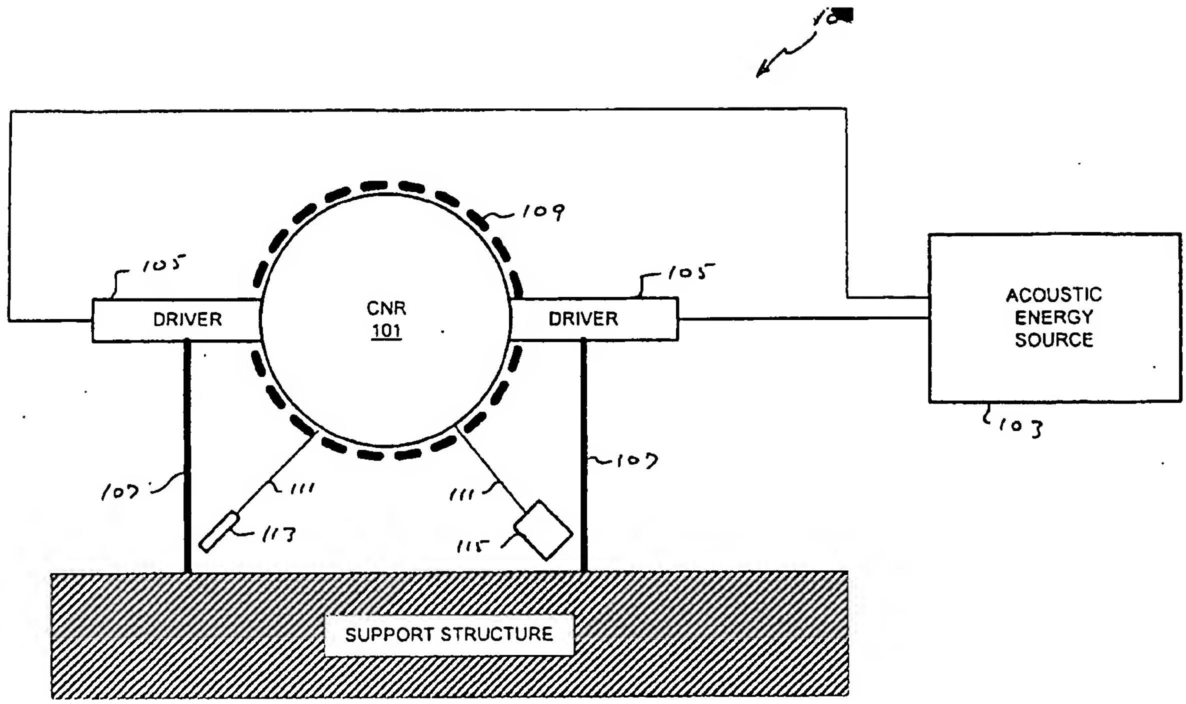

FIG. 1

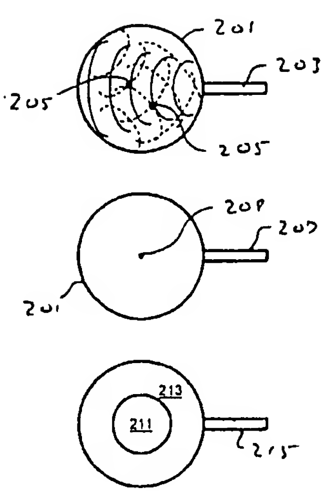

FIG. 2

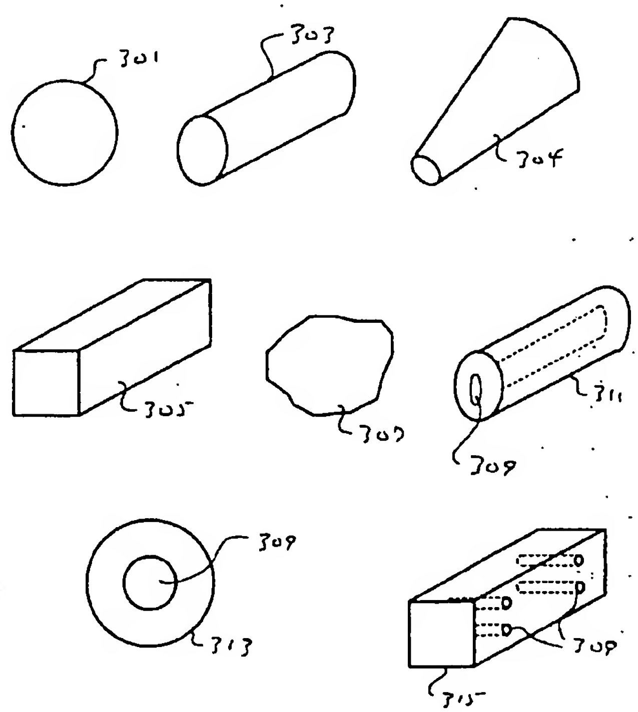

FIG. 3

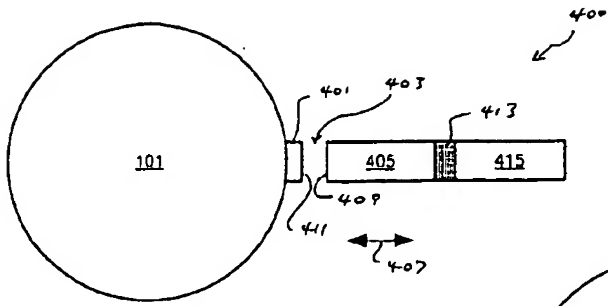

FIG. 4

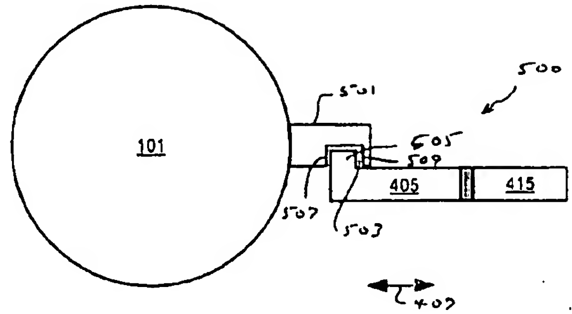

FIG. 5

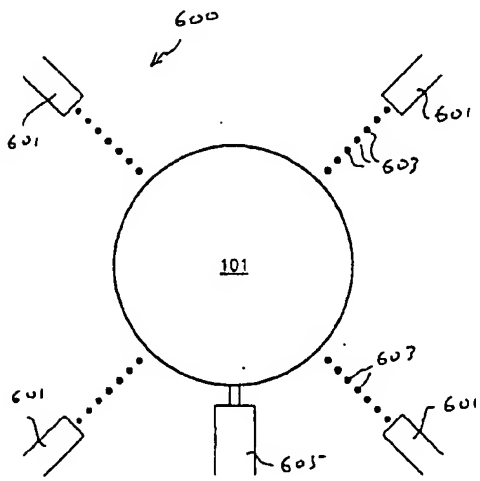

FIG. 6

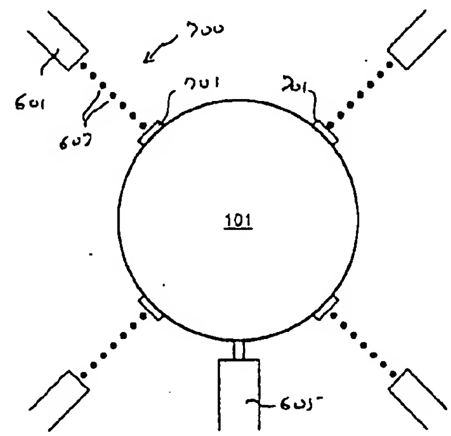

FIG. 7

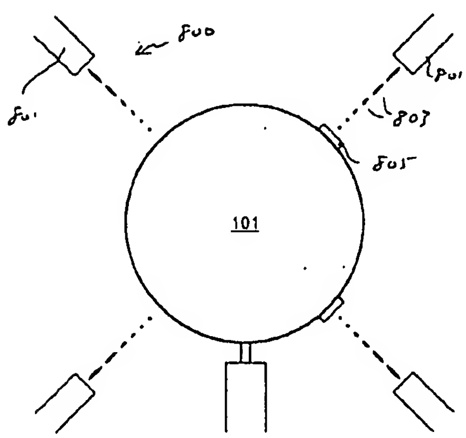

FIG. 8

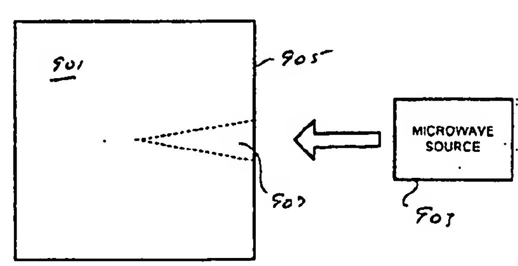

FIG. 9

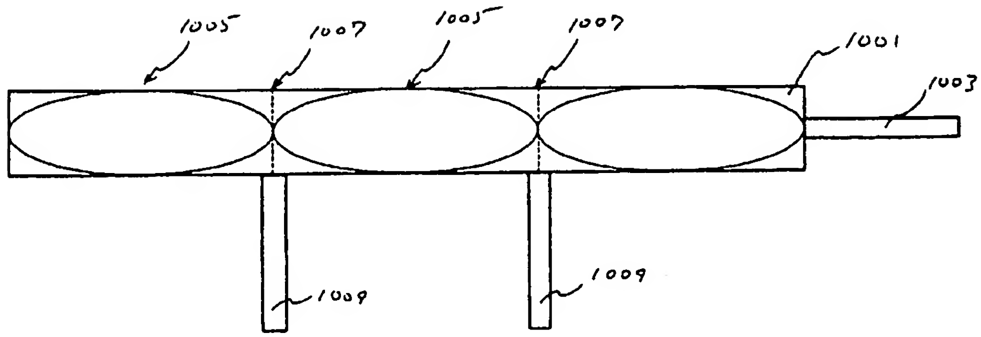
1005
1007
1005
1007
1001
1003
1009
1009

FIG. 10

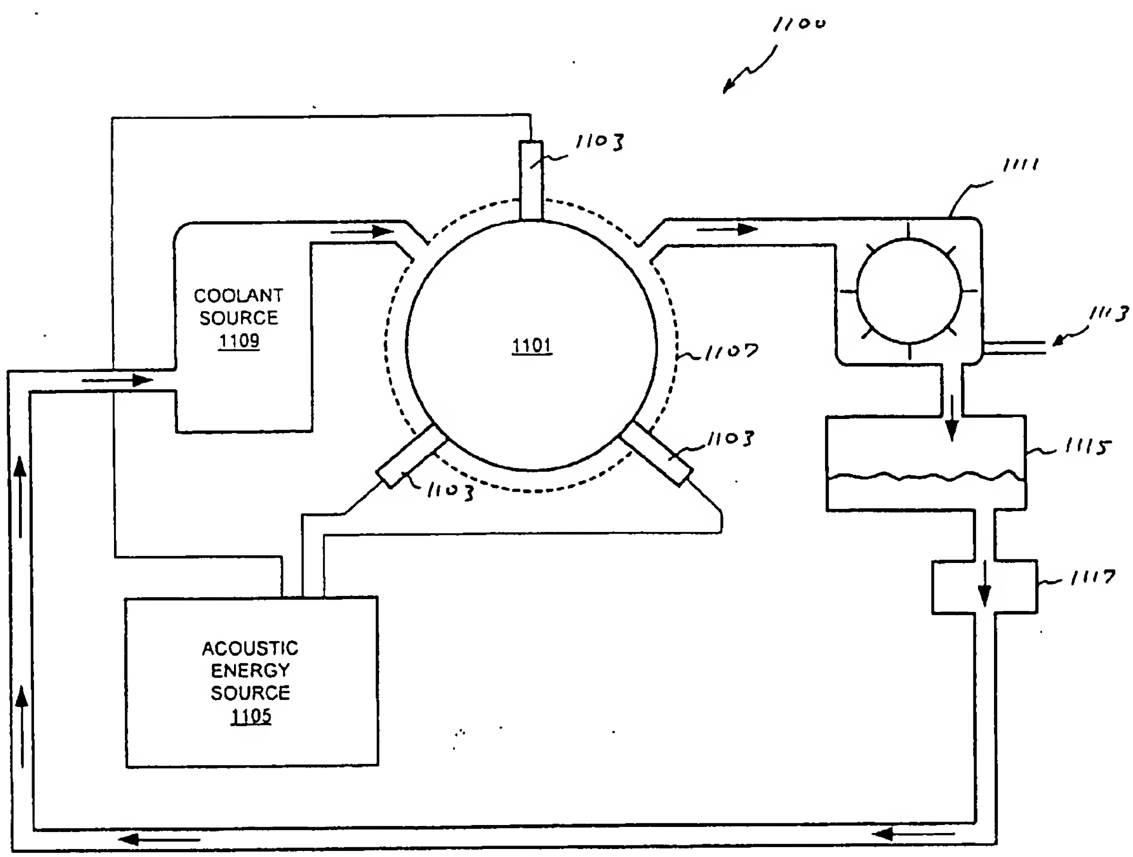
1100
1103
1111
COOLANT
SOURCE
1109
1101
1107
1113
1103
1115
1103
1117
ACOUSTIC
ENERGY
SOURCE
1105

FIG. 11

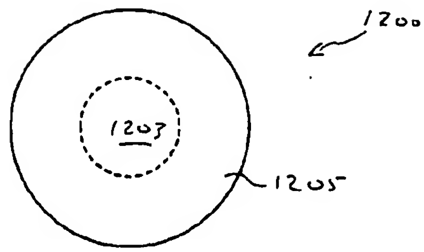

FIG. 12

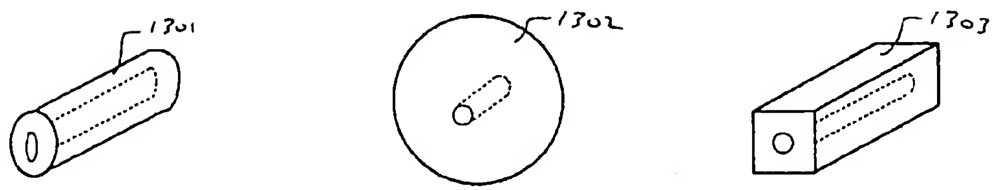

FIG. 13

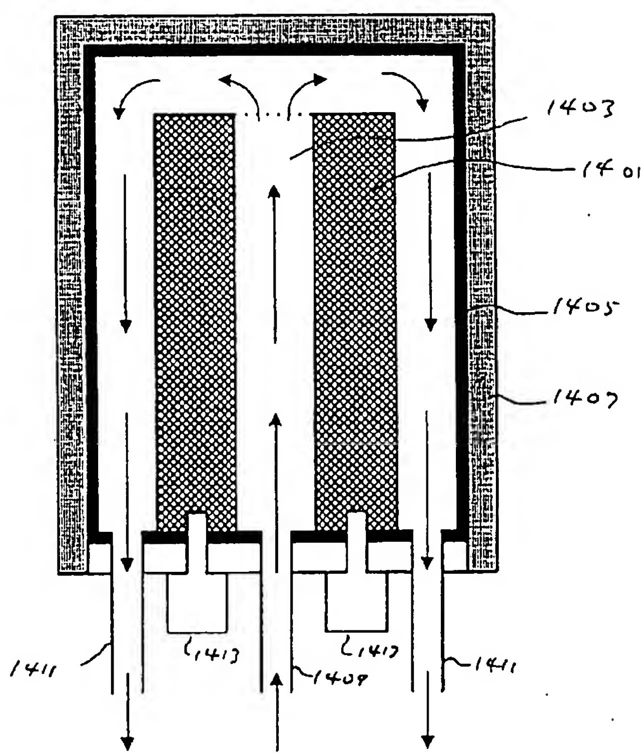

FIG. 14